REPORT #
RRTAC 90-6

Proceedings of the Industry/Government Three-Lift Soils Handling Workshop

Heritage Fund

Alberta

LAND CONSERVATION AND
RECLAMATION COUNCIL
Reclamation Research
Technical Advisory Committee

Alberta's Reclamation Research Program

Regulating surface disturbances in Alberta is the responsibility of the Land Conservation and Reclamation Council. The Council executive consists of a Chairman from Alberta Environment and two Deputy Chairmen from Alberta Forestry, Lands and Wildlife. The Council oversees a reclamation research program, established in 1978, to identify the most efficient methods for achieving acceptable reclamation in the province. Funding for the research program is provided by Alberta's Heritage Savings Trust Fund, Land Reclamation Program.

To assist with the development and administration of the research program, the Council appointed the inter-departmental Reclamation Research Technical Advisory Committee (RRTAC). The Committee consists of eight members representing the Alberta Departments of Agriculture, Energy, Forestry, Lands and Wildlife, and Environment, and the Alberta Research Council. The Committee updates research priorities, reviews research proposals, organizes workshops, and otherwise acts as the coordinating body for reclamation research in Alberta.

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RRTAC 90-6

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PROCEEDINGS OF THE INDUSTRY/GOVERNMENT

THREE-LIFT SOILS HANDLING WORKSHOP

Prepared by

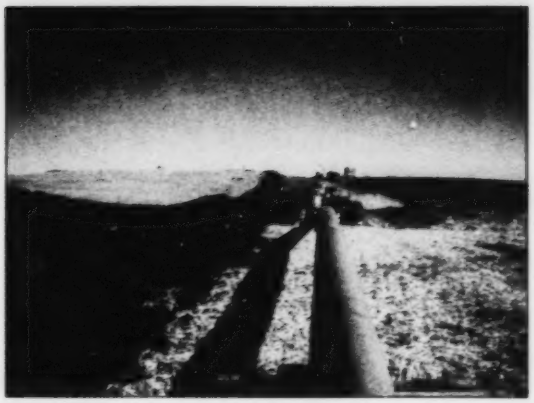
Deloitte & Touche

Prepared for

ALBERTA LAND CONSERVATION AND RECLAMATION COUNCIL
(Reclamation Research Technical Advisory Committee)

1990

Oil and Gas Reclamation Research Program



Members: Chris Powter (Chairman) - Alberta Environment; Lilli Chevrier (Secretary) - Alberta Environment; Richard Coleman - Alberta Environmental Centre; Roger Creasy - Energy Resources Conservation Board; Al Fedkenheuer - NOVA Corporation of Alberta; Jim Fujikawa - Alberta Environment; Arnold Janz - Alberta Environment; David Lloyd - Forestry, Lands & Wildlife; Leon Marciak - Alberta Agriculture; Doug Mead - Shell Canada Resources Limited; Gary Mott - Bow Valley Industries Ltd.; Sam Takyi - Forestry, Lands & Wildlife.

DISCLAIMER

This report is intended to provide government and industry staff with up-to-date technical information to assist in the preparation and review of Development and Reclamation Approvals, and development of guidelines and operating procedures. This report is also available to the public so that interested individuals similarly have access to the most current information on land reclamation topics.

The opinions, findings, conclusions, and recommendations expressed in this report are those of the author(s) and do not necessarily reflect the views of government or industry. Mention of trade names or commercial products does not constitute endorsement, or recommendation for use, by government or industry.

REVIEWS

This report has been reviewed by members of the Reclamation Research Technical Advisory Committee and the Oil and Gas Reclamation Research Program Committee. RRTAC also wishes to thank members of the Alberta Pipeline Environment Steering Committee for their reviews.

GLOSSARY OF TERMS

The following terms are used in this report.

Horizon Layers in a typical mineral soil profile are often referred to as horizons. The major horizons are labelled A, B, and C, and there may be further subdivisions of these layers. The A horizon is found at the soil surface, contains the most organic matter, and is considered to be the layer with the best characteristics for plant growth. The A horizon is often called the topsoil. The B horizon occurs below the A horizon and is usually intermediate in quality between A and C horizons. The C horizon is most similar to the underlying parent material and is, in some cases, composed of materials that are not suitable for plant growth.

B/C Horizon This is used to indicate a mixture of these two horizons when excavated together during pipeline construction.

Control Section The vertical section of the soil upon which classification or evaluation is based. The depth will vary depending on the purpose or system being used.

Over-stripping The intentional stripping of the upper B horizon with the A horizon. This would only be done where incorporation of the B horizon would not significantly degrade the quality of the A horizon. This procedure may be suitable for areas with a shallow A horizon and good quality B horizon.

Ploughing-in A procedure whereby the pipe is placed into the ground in one pass by creating a furrow with a very large plough and inserting the pipe to depth. This procedure is advantageous because there may be less disturbance to the land surface.

Boring A procedure occasionally used for road and railway crossings, whereby a tunnel is bored under the soil and the pipe is inserted. This procedure may be possible to implement on a much larger scale but will likely be very expensive. It has been done with some success on steep river banks in the past.

Landfarming A procedure whereby a waste is added to the soil surface. Landfarming should only be considered where the waste will have a neutral or positive effect on soil quality. The term for the addition of a waste which may negatively affect the soil is land spreading, and this is not considered to be a proper use of the soil. Thus, land spreading of excess spoil may not be acceptable.

Aboveground pipe Rather than place the pipe in the ground it may be practical to place it on the soil surface or suspend it on some form of permanent structure.

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EXECUTIVE SUMMARY

Three-lift Soils Handling Workshop

An industry/government workshop on the three-lift soil handling procedure was held on November 29 and 30, 1990 at the Lodge at Kananaskis. As outlined in the opening comments by Ian Scott, Canadian Petroleum Association, and John King, Alberta Environment, the workshop provided an opportunity for industry and government to communicate on significant issues relative to the three-lift process. The workshop was a combined industry/government undertaking. Government, through RRTAC, provided for Mr. Don Hoover and Ms. Lorrie McFadden of Deloitte & Touche to act as facilitators for the workshop; IPAC and CPA provided lunches for the two days, and the CPA coordinated the organization of the event. Funding for RRTAC comes from the Alberta Heritage Savings Trust Fund, Land Reclamation Program.

The workshop included presentations on the first day, and working group discussions on the second day. The presentations covered the following topics:

1. Definitions and Scope of the Workshop.
2. Overview of Industry and Government Positions.
3. Three-lift Rationale.
4. Field Data to Support Positions.
5. Soil Handling Methods for Two-lift and Three-lift.

On the second day, the working groups addressed four items:

1. What soil handling/conditioning alternatives exist to resolve concerns addressed by the three-lift procedure?
2. Comments on Interim Criteria for use of three-lift procedures.
3. Terms of Reference for developing research proposals to assess the effectiveness of three-lift soil handling: goals, measurement parameters, and field design.
4. Discussion of definitions.

The main points presented by the working groups under each of these headings are outlined below.

Soil Handling Alternatives. It is generally accepted that three-lift or an alternative to two-lift is required in some cases. Several soil handling alternatives were identified to resolve concerns addressed by the three-lift procedure. All of the alternatives were thought to have merit, but research may be needed in some cases to assess applicability to specific situations. The main alternatives identified included:

1. Plough-in.
2. Narrow ditch/minimum disturbance.
3. Boring.
4. Two/three-lift for winter.
5. Overstripping.
6. Management over time (cultural, with and without amendments).
7. Incorporation of B/C mix.
8. Landfarming of excess spoil.
9. Amelioration.

Interim Criteria. Both industry and government want clear criteria for materials handling decisions. The general opinion was that the Interim Criteria need to be modified. The main areas of concern are outlined below.

1. Modifiers for the criteria should include considerations such as land use, length of area affected, depth, thickness, soil properties, bedrock texture, geography, and topography. At present, the class boundaries are arbitrary, and no consideration is given to the relative importance of the parameters.
2. Regarding the lift thickness, it was suggested that there may be a need for a minimum and a maximum thickness for the B horizon, and a specified depth to buffer the A horizon.
3. There was support for criteria using a sliding scale, similar to that used in the 1985 draft criteria. Boundaries of the current soil quality classes were not considered suitable.
4. It was suggested that the soil map unit is an appropriate handling unit to use.
5. The criteria "50% of the site inspections" should be altered to be "50% of the soil map unit", and the 50% is considered to be arbitrary. ("Site

inspections" leaves a great deal to surveyor discretion.) Sampling must address soil variability.

6. The criteria could include a caveat that industry have the option of doing a detailed soil survey if a preliminary survey indicated the three-lift procedure was required.
7. The criteria, as presented, may be appropriate for gravel and bedrock, but need revision for saline/sodic soils.

Research Proposals. It was indicated that research should be co-funded by industry and government. The research program should be designed to meet a goal. The goal identified was to determine whether there was a significant difference between two-lift and three-lift in maintaining capability. The following research needs were identified:

1. Any existing information that is applicable should be accessed (i.e., mining data, as-built reports); in addition, a survey of existing pipelines (since 1980) could be undertaken to gather information such as the effect of time, and the relative influence of the parameters.
2. A monitoring program should be set up for new pipelines to gather data on approved and alternate handling procedures. A database of this information should be developed, and would provide a basis for refinement of the guidelines. Monitoring of the lines could be a condition of approval for the lines (on a limited number of lines per year per company). A standard sampling/monitoring procedure would be required to assure comparability of data.
3. A monitoring study of 10 to 12 sites over three to four years, or as required, comparing three-lift sites and pre-disturbance conditions.
4. Additional pure research is needed to address topics such as productivity versus capability, depth to poor quality, use of amendments, B/C mix ratios, salt movement and time frame, additional disturbance versus three-lift benefits, equipment requirements, etc. Standard sampling and testing methodology would be required to address these needs.
5. After the detailed research is completed, the criteria should be evaluated and revised as necessary.

Definitions. Only some of the groups discussed the definitions in any detail. It was generally agreed that the definitions need to be revised, and that agreement on the definitions can be reached. Review of the definitions should be referred to a working group such as the Three-lift Task Force.

The closing comments for the second day gave a good overview of the workshop. It was indicated by both government and industry that increased trust between the two groups must be encouraged. There was a need to present the positions of the two groups, and this workshop allowed that to happen. What is needed now is continued communication between the two groups. There was open communication at the workshop and progress was made. Many issues and points that need to be addressed were identified, as outlined above. These points must be addressed, with input by some combination of government/industry/private consultants, so that further progress can be made.

1. INTRODUCTION

An industry/government workshop on the three-lift soil handling procedure was held on November 29 and 30, 1990 at the Lodge at Kananaskis. As outlined in the opening comments by Ian Scott, Canadian Petroleum Association (CPA), and John King, Alberta Environment, the workshop provided an opportunity for industry and government to communicate on significant issues relative to the three-lift process. The workshop was a combined industry/government undertaking. Government, through the Reclamation Research Technical Advisory Committee (RRTAC), provided for Mr. Don Hoover of Deloitte & Touche to act as facilitator for the workshop; Independent Petroleum Association of Canada (IPAC) and Canadian Petroleum Association provided lunches for the two days, and the CPA coordinated the organization of the event.

The workshop included presentations on the first day, and working group discussions on the second day. The presentations covered the following topics:

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2. Comments on Interim Criteria for use of three-lift procedures.
3. Terms of Reference for developing research proposals to assess the effectiveness of three-lift soil handling: goals, measurement parameters, and field design.
4. Discussion of definitions.

The Agenda for the Workshop is outlined in Figure 1.

Figure 1. Agenda - Three-lift Soils Handling Workshop, November 29 & 30, 1990

Thursday November 29 PRESENTATIONS

1. Opening Remarks
   John King and Ian Scott
2. Definitions and Scope of Workshop
   Chris Powter
3. Overview of Government and Industry Positions
   John King and Bob Seager
4. Three-lift Rationale
   Travis Ferguson
5. Field Data to Support Positions
   Arnold Janz and Al Fedkenheuer
6. Soil Handling Methods for Two-lift and Three-lift
   Bob Onciul and Mike Houser
7. Discussion
8. Wrap-up - Consultant

Friday November 30 WORKSHOP

1. Working Groups
2. Presentation of Working Groups
3. Presentation of Working Groups
4. Action Plan and Wrap-up

2. SUMMARY OF PRESENTATIONS

2.1 OPENING REMARKS

The Three-lift Soils Handling Workshop was opened by John King, Director, Land Reclamation Division, Alberta Environment, and Ian Scott, Senior Coordinator - Pipeline Division, Canadian Petroleum Association.

Mr. King and Mr. Scott indicated that the workshop was initiated to provide an opportunity for industry and government to communicate on the significant issues pertaining to three-lift soil handling; the main goal of the workshop being to move toward a common understanding of the issues and concerns.

Mr. King indicated that the organization to address issues such as these was in place through the Alberta Pipeline Environmental Steering Committee. This committee has identified up to twenty-five issues to be addressed. Task Forces will be created to address some of the issues, and a Three-lift Task Force is one of these.

Mr. King's comments are outlined in detail in Appendix 5. Mr. Scott's comments are outlined in detail in Appendix 6.

2.2 DEFINITIONS AND SCOPE OF WORKSHOP

2.2.1 Definitions Proposed by Government

Mr. Chris Powter, Chairman, Reclamation Research Technical Advisory Committee, presented the definitions proposed by government. These definitions are outlined in Appendix 7.

2.2.2 Industry Comments on Definitions and Scope

Mr. Powter then presented the comments received from industry on the proposed definitions. Industry's comments are outlined in Appendix 8.

2.2.3 Questions

Discussion of the definitions revolved around the concept of capability and its applicability, versus the concept of productivity. The government position is that soil should

be returned to as close to its previous capability as possible. Productivity is, to a large degree, a function of management, and is therefore a separate issue. Productivity is one tool in assessing soil capability, but is not the only one. Discussion detail is outlined in Appendix 9.

2.3 OVERVIEW OF GOVERNMENT AND INDUSTRY POSITIONS

2.3.1 Government Position

Mr. John King, Director, Land Reclamation Division, Alberta Environment, presented the government position on three-lift soil handling.

The three-lift discussion is not new, but has come up again because some larger lines have been put in recently. The pipelines to which three-lift applies are, as a percentage of length and number of total pipelines constructed, a low percentage of the total.

The Government of Alberta Mission Statement relating to the environment has as one of its main principles that the government will use leading edge technology in the development of conservation and reclamation standards. The government is concerned with soil capability, and wants to prevent soil deterioration relating to pipeline activity. In a case where capability is reduced, it is questionable whether certification can take place, and the security deposit be returned.

There is a need to clarify terms such as conservation, reclamation, restoration and preservation. What government wants to do is not preservation, but there is a need to practice reclamation and conservation to maintain equivalent capability.

Government sees three-lift as one approach that will work, and therefore, is buying into it. Other ideas might also work successfully, and this is open to discussion.

The Interim Three-lift Criteria have been developed by government, but government wants industry to agree with any regulations implemented. There is a need to understand the three-lift procedure and to work towards a more scientific approach. Government supports the workshop process as a step towards this goal.

Government's overall objective is to achieve proper environmental protection of the soil resource - this is what the public expects.

A detailed outline of Mr. King's presentation is included in Appendix 10.

2.3.2 Industry Position

Mr. Bob Seager, Supervisor of Environmental Protection - Construction, NOVA Corporation of Alberta, presented the industry position on three-lift soil handling.

Industry's position was developed through meetings of CPA and IPAC members, with the assistance of Len Knapik of Pedocan.

2.3.2.1 Guiding Principles. As stated in the CPA Environmental Code of Practice, industry is committed to the policy of protecting the environment. Industry is willing to use procedures that are practical and result in demonstrated benefit to the environment, and is willing to change construction and operating practices where a need to change is demonstrated. Industry is committed to support research, and committed to working with government when they are developing laws, regulations and guidelines. Industry would like to see clearly defined philosophy and stated standards of soil reclamation. Two-lift is the accepted procedure, and before three-lift is accepted as a procedure, the benefits must be clearly demonstrated.

2.3.2.2 Assessment of Need to Change Soil Handling Practices. Overall, industry identified a requirement for research to clarify and quantify the need for changing soil handling practices.

Many questions were raised as to the extent of the problem, the impacts and the extent of the impacts. Documentation relating to these problems and impacts is needed. The issues to be addressed include:

1. Trade-offs of alternate construction practices need to be investigated.
2. Clarification is needed on the extent to which saline-sodic soils are self-reclaiming.
3. Criteria for successful soil reclamation are needed.
4. Additional cost of the three-lift procedure must also be addressed.

2.3.2.3 Industry's Position on Three-lift. Industry recognizes that certain soils have strongly contrasting, undesirable subsoil layers, and could warrant alternate construction practices. These soils include:

1. Soils with desirable upper subsoil overlying gravel or coarse sand lower subsoil.
2. Soils with desirable upper subsoil overlying weathered bedrock (soft mudstone or shale) that has very undesirable characteristics.
3. Soils with desirable upper subsoil overlying subsoil that is strongly saline, is strongly sodic, or is strongly saline-sodic. The position of the soil in the landscape, the ecoclimate, and the land use must be considered in addition to soil profile data in determining the appropriate construction practice.

Industry believes the Interim Criteria are inappropriate and should be withdrawn. Appropriate criteria should be developed based on appropriate standards and research findings.

Several topics were identified as requiring research, mainly relating to establishing:

1. Appropriate criteria.
2. Appropriate procedures.
3. Appropriate standards.
4. A soil monitoring process.
5. New techniques to minimize soil impacts.

Industry is willing to participate in a properly designed research project to address issues such as these.

2.3.2.4 Concluding Statements. Industry favours a consultative, scientific approach to development and implementation of new guidelines and regulations. Guidelines should be developed outside the application approval process.

Government should identify areas where further work is needed, but should not unilaterally specify techniques, as alternate techniques may be available.

Industry and government should work together to develop practical and effective guidelines and efficient approval processes to maximize benefits to the environment.

A detailed outline of Mr. Seager's presentation is included in Appendix 11.

2.3.3 Questions

Questions on the overview of government and industry positions centred around several issues, including:

1. Process involved in developing each position.
2. The effect of time on capability.
3. Clarification of terms used.

Discussion detail is outlined in Appendix 12.

2.4 THREE-LIFT RATIONALE - THREE-LIFT SOIL HANDLING FOR PIPELINES IN ALBERTA

Mr. Travis Ferguson, Soil Scientist, Alberta Environment, presented the paper on the three-lift rationale.

2.4.1 Rationale for Three-lift

Both conservation and reclamation are part of industry's ongoing operations, but Alberta Environment focuses on conservation.

Alberta Environment considers the entire soil profile when evaluating soils for materials handling. Topsoil and subsoil are two components that directly affect soil capability. The operator should handle all materials in a manner to ensure a rootzone that is capable of supporting sustained plant growth. This may include selective removal of the soil horizons, reclamation, etc.

2.4.2 Definitions/Background

Several definitions were presented as background. See Appendix 13.2.

2.4.3 Land Capability Classification for Arable Agriculture in Alberta

This system was designed to replace the old C.L.I. rating system, and is composed of 7 classes and 21 subclasses defining and quantifying limitations for the components of climate, landscape and soil.

This rating system is not used presently due to limitations in the system.

2.4.4 Soil Quality Criteria Relative to Disturbance and Reclamation - 1987

The purpose of the 1987 document is to provide criteria for material quality assessment prior to disturbance and subsequent to reclamation with the goal of minimizing environmental impact occurring as a result of land disturbances.

Materials handling techniques and soil replacement are site specific. Using this system, with selective soil handling, the goal of maintaining soil capability can be achieved.

2.4.5 Three-lift Soil Handling Criteria

The following are interim criteria used to evaluate three-lift soil handling procedures for pipeline construction in Alberta.

1. The predicted post construction soil rating of two-lift handled soils is at least one soil suitability class less than three-lift handled soils. (Soil Quality Criteria Relative to Disturbance and Reclamation, 1987)
2. At least 50% of site inspections within a soil unit must demonstrate the need for three-lift soil handling (as per #1 above) before it is required.
3. The second lift thickness is at least 15 cm.
4. Soil handling unit length is the equivalent of one soil map unit delineated at the series level of soil classification.

Detailed Analysis of Criteria.

1. Soil Rating System. The Soil Quality Criteria document, specifically material suitability requirements, were chosen as text to evaluate material for three-lift applicability for the following reasons:
   a. This is a published, widely used document developed by a working group composed of government and industry.
   b. This document was developed to consider all types of surface disturbances and subsequent reclamation.
   c. This document considers the soil properties that could have a bearing on overall soil capability.
   d. This document characterizes soil properties into material suitability classes that can be used to determine soil handling requirements.

2. Soil Unit Site Inspections. Site inspections are used by soil surveyors to confirm the presence of a specific type of soil. Site inspections are thus representative of soils found in a soil unit. The dominant soil found in a particular map unit is used to evaluate the soil handling procedure for that map unit.

   Soils are mapped and described on a site specific basis at a predetermined intensity level. Thus for a particular project, similar soils (soil series) should have similar materials handling procedures.

   The minimum 50% criteria was developed in an attempt to discern a reasonable materials handling procedure for a specific soil unit.

3. Minimum 15 cm Second Lift. The minimum 15 cm second lift thickness was initiated for two reasons:
   a. Present day materials handling equipment can consistently and accurately salvage a 15 cm second lift of soil.
   b. Soil capability may not be improved if the second lift thickness is less than 15 cm.

4. Soil Handling Unit Length. In regulated pipeline construction, soils information is collected at a soil survey intensity level one to three. (Information Requirements for Regulated Pipeline, 1988)

   Using the predetermined soil survey intensity level and other factors identified during the survey, soil map unit boundaries are delineated. Soil delineations and boundaries separate dissimilar soils (different soil map units). The minimum size of these soil map units correspond to the minimum soil handling unit length.

2.4.6 Problem Soils for Three-lift

There are two main types of soils requiring separate handling of soil horizons to maintain soil capability.

If gravel occurs within the pipeline trench, it should be replaced at pre-construction depths. Any gravel replaced closer to the surface could cause soil capability reduction. Gravel can be found throughout the province.

Salinity or sodicity may require three-lift soil handling when they exist below a non-saline/non-sodic subsoil layer. Salinity and sodicity can be found almost anywhere within the White Zone of the province.

Examples of three-lift and two-lift soils are outlined in Appendix 13.7 and 13.8 respectively.

2.4.7 Summary and Conclusions

Soil conservation is a primary goal of Alberta Environment. Wise use of the environment implies conservation as an important factor governing the use of resources to ensure our quality of life is sustained for future generations. Alberta Environment also stresses that environmental protection requires anticipation and prevention. The Alberta Government requires land to be reclaimed following development activity. Reclamation is an integral part of industry's ongoing operations; Alberta Environment insists that it be preplanned.

Alberta Environment recognizes that not all past protection efforts have been successful. To improve on these problems, Alberta Environment uses research and leading edge technology in the development of conservation and reclamation standards. Three-lift soil handling is one alternative to achieve the construction and reclamation goals.

A detailed outline of Mr. Ferguson's presentation is included in Appendix 13.

2.4.8 Questions

Questions on the three-lift rationale centred around several issues, including:

1. The effect of time on soil formation and capability.
2. Methodology used in preparing the data presented.
3. The guidelines, classification systems and parameters used.
4. The trade-off between minimum soil disturbance and the three-lift issue.
5. Subjectivity in the assessment.
6. Economic justification for three-lift.

Discussion detail is outlined in Appendix 14.

2.5 FIELD DATA TO SUPPORT POSITIONS

2.5.1 An Evaluation of Two-tiered Soils in Alberta for Three-lift Handling

Mr. Arnold Janz, Soil Specialist, Land Reclamation Council, Alberta Environment, made the presentation for government.

2.5.1.1 Rationale for Three-lift Handling. Because of the relatively short history of oil and gas development in Alberta, long-term (many decades) impacts of oilfield and pipeline development on soil resources have not been adequately evaluated nor understood. On the basis of field experience and soil conservation principles, it has become evident that the "topsoil" approach to soil conservation must be replaced by the "whole-soil" approach if soil capability is to be maintained for the long term.

Soil conservation has been defined as: "the combination of all methods of management and land use that will protect the soil against physical loss or depletion, and chemical deterioration by natural and man-influenced factors" (from "Soils of Canada" glossary). This principle recognizes the inherent value of a soil as a whole and in its parts, regardless of its geographic location, landscape position, land use or economic contribution.

The principle also recognizes the following:

1. The extent of the soil resource is limited.
2. The extent of the soil resource is diminishing.
3. Soils are sensitive, easily damaged and difficult to repair.
4. The long-term effects of development are not well known.
5. The soil resource is an integral component of the ecosystem.
6. Soils in different locations and landscape positions should not necessarily be handled alike.
7. Soil resources must be conserved for future generations.

The acceptance of the soil conservation principle has several significant implications for soil management including:

1. Conservation of the quality and characteristics of the whole-soil and its components is required.

2. Conservation must be preplanned on the basis of whole-soil and component quality.
3. Conservation procedures should be preplanned and accompany development stages of the operation rather than rely on reclamation or repair procedures after operation completion.
4. Conservation efforts for each soil zone (horizon) must be proportional to the value of that zone as a root medium for all crop types suitable for the region.

Research results from the Battle River Soil Reconstruction Project - Subsoil Depth Experiment and general research findings regarding salinity were presented to support the three-lift rationale. Details of the research presented are outlined in Appendix 15.2.2 and 15.2.3.

2.5.1.2 Description of Potential Three-lift Soils. Potential three-lift soils are those which, in their undisturbed state, have three distinctly different zones within the profile which have developed on at least two different geologic materials (an upper and a lower tier). Three distinct zones include topsoil, midsoil (upper subsoil) and lower subsoil.

The upper tier usually contains the favourable topsoil and midsoil materials. It is generally less than 1 m thick, stone-free, contains some organic matter, is coarser textured than the lower subsoil, brown in colour, and non-saline and non-sodic.

The lower tier material occurs in the lower part of the soil profile under the upper tier at any depth below approximately 25 cm. It is generally of unfavourable quality for reclamation relative to the upper tier. It may be composed of one of several different materials including gravel (glacio fluvial outwash), clay (lacustrine), clay loam till, rock (bedrock), sandstone or mudstone (residual). Till, lacustrine and residual materials may be saline and sodic.

Seven different potential three-lift soil types have been identified. They are differentiated on the basis of geologic origin and quality for reclamation. Types 1, 2 and 3 are differentiated on the basis of chemical limitations in the lower tier, while Types 4 to 7 are differentiated on the basis of physical limitations in the lower tier. (See Appendix 15.3.2).

2.5.1.3 Impact Assessment of Two-lift Procedure on Potential Three-lift Soils. An estimate of the effects of a specific two-lift operation is essential in order to determine if three-lift is necessary. This should be an important component of the developer's planning process. Impact estimates must consider the following:

1. The short term effects.
2. The long term effects.
3. The effects across the entire right-of-way including work, trench and spoil areas.
4. The effects on the topsoil.
5. The effects on the midsoil.
6. The combined effects on the whole-soil.

The accuracy of the impact assessment process is dependent on several important aspects of development procedures including:

1. Width of excavation.
2. Depth of excavation.
3. Degree of material bulking.
4. Type of excavation equipment.
5. Lower subsoil characteristic and thickness.
6. Midsoil characteristics and thickness.
7. Topsoil thickness.
8. Soil moisture conditions during materials handling.
9. Sampling intensity.

The planning process should incorporate as much of this information as possible in the impact assessment for three-lift determination.

It is estimated that risks of topsoil degradation will be increased significantly if two-lift is selected instead of three-lift. The risk of degradation is highest in areas with shallow replaced topsoil, or an elevated roach. Some observations indicate that topsoil degradation occurs through loss of organic matter, increased salinity and sodicity, and increased gravel, clay or rock.

Two different types of degradation should be expected in the upper subsoil. The first is a result of replacement of favourable materials with unfavourable spoil mix directly

under the topsoil, and the second is a result of spoil material stratification in areas beside the trench.

2.5.1.4 The Geographic Distribution of Three-lift Candidate Soils. Potential three-lift soils occur throughout Alberta, but for the main part, occur in the agricultural regions of the province.

2.5.1.5 Summary. Two-tiered soils, as described in this report have unique characteristics for which special soil handling techniques are essential in order to prevent their degradation. These soils are usually easily recognized in the field through identification of one main characteristic - the presence of a favourable midsoil zone between the topsoil and unfavourable lower subsoil. Separate handling of topsoil, midsoil and subsoil when preplanned and properly implemented, will ensure conservation of favourable midsoil quality at its preconstruction depth, and ultimately conservation of the "whole-soil".

The three-lift technique is presently utilized in Alberta and elsewhere in various industrial activities including coal mines, sand and gravel operations, industrial site development and pipelining. Use of the three-lift technique and its applicability to certain industrial activities demonstrates the increased awareness by government and industry of the importance of the "whole-soil", the need to carefully manage and conserve soil resources, and a willingness to apply the best available technology and equipment toward soil conservation. As this trend continues, it could become incorporated as a standard operating procedure for a wide variety of industrial site development activities. Technological improvements and increased efficiencies are expected to accompany the procedure as it matures.

A detailed outline of Mr. Janz's presentation is included in Appendix 15.

2.5.2 Pipeline Construction in Soils With "Problem" Subsoil Layers - An Industry Perspective

Mr. Al Fedkenheuer, Senior Specialist - Reclamation, NOVA Corporation of Alberta, made the presentation for industry.

The first question that needs to be addressed is the extent of soil problems caused by pipeline construction. There is a need to determine the types of problems existing on these pipelines, taking into consideration the date of construction of the lines. Construction date is important since soil handling techniques have improved since the early 1980's. The severity of the problems and their location (e.g., geographic location, climatic zone, soil type) should also be assessed.

Once this analysis is undertaken it will be possible to address the question of how many of the problems are due to incorrect subsoil handling techniques.

2.5.2.1 Literature Review. The literature concerning pipelining and its impacts in Alberta and Saskatchewan generally does not support the view that pipelining creates extensive soils problems. Several studies were cited.

2.5.2.2 Field Data. NOVA initiated a study in 1983 in three areas designated by Alberta Environment as requiring a three-lift soils handling procedure. In each area designated as requiring three-lifting, one-half was constructed using an approved "state-of-the-art" three-lift procedure and the other one-half of each of the three areas was constructed using a conventional two-lift procedure.

This Standard Lateral research indicates that, in the three areas studied, for the study soils which were two-lifted, Electrical Conductivity (E.C.) levels were similar to those of off-right-of-way soil samples three to five years after pipeline construction. Sodium Adsorption Rate (SAR) levels in the trench samples were also comparable to levels in control soil samples after three to five years.

Another study on the Battle River section of NOVA's North Lateral Extension #2 compared E.C. and SAR on pipelines constructed in 1972, 1976, and 1990. It should be noted that little information on the construction techniques used on the 1972 and 1976 lines is available. The study found that E.C. and SAR levels in soils at the pipelines installed in 1972 and 1976 were at acceptable levels for the three depths sampled. Levels in the adjacent 1990 pipeline are higher than desirable, but are expected to decrease to acceptable levels based on experience elsewhere with two-lift soils.

Due to the lack of research on pipelines, and relatively more abundant research on open pit mines, there is a tendency to take results from mining research and apply them directly to pipelining. There are major differences in the type of disturbance created by mining as compared to pipelining. Therefore, extreme caution must be used in making interpretations of mining data to apply to pipeline situations.

2.5.2.3 Prediction of Soil Performance. There is a need to develop appropriate criteria for identifying soils with strongly contrasting, undesirable subsoil layers. The current Interim Criteria are considered inappropriate. Problems with these criteria are the inclusion of pH, equal consideration of all criteria, and inter-relation of criteria used. Also, the classes are too rigid, and do not bring soil spatial or temporal variability into the equation.

For these reasons, it is recommended that the criteria for undesirable subsoil found in the draft "Manual on Soil Conservation Procedures for Pipeline Construction on Agricultural Lands" be implemented in place of the Interim Criteria. These criteria are based on strongly contrasting, undesirable properties, and use a sliding scale to change from one class to another rather than a rigid boundary. The primary properties are E.C., SAR and Stone Content and take into account soil variability in space and time.

Other steps which are needed include:

1. Development of appropriate models for predicting post-construction soil quality using pre-disturbance information.
2. Development of appropriate post-construction soil quality standards.
3. Using the criteria developed, a "Soil Reclamation Planning Database" should be put in place. This would include recommended soil handling procedures and other practices for each soil series in the province.
4. A systematic monitoring program should be established to more clearly define what problems exist and/or are being created. These "as-built" reports would cover soils, crops and related problems.
5. Soil handling plans should be developed within pipeline Development and Reclamation applications using recommended practices for each soil

series. A proposed exception would require an alternative practice be presented and rationalized.

2.5.2.4 Data Gaps. Several gaps in available data were identified which should be rectified. These include:

1. A need to quantify the problem with respect to the soil type and other factors. Collecting data from "good" situations would provide an indication of how to improve practices/techniques.
2. Collection of monitoring data for soils and crops on pipelines through "as-built" reports would help improve the database.
3. Research data are needed to understand the effects of mixing soil horizons and the interactions of soil properties.

2.5.2.5 Concluding Comments. This presentation attempted to identify things which are unknown, as well as identifying problems with using the existing Interim Criteria. Data were also presented to support the suggestion that over time E.C. and SAR levels will decrease to off-right-of-way levels when the two-lift procedure is used.

A complete outline of Mr. Fedkenheuer's presentation is included in Appendix 16.

2.5.3 Questions

Questions on the Field Data presentations centred around several issues, including:

1. Methodology used in obtaining the study results presented.
2. Discussion of soil properties, including E.C. and SAR.
3. Limitations of the data presented and the study methodology.

Discussion detail is outlined in Appendix 17.

2.6 SOIL HANDLING METHODS FOR TWO-LIFT AND THREE-LIFT

2.6.1 Government Perspective

Mr. Bob Onciul, Senior Reclamation Officer, Alberta Environment, made the presentation for government.

The main objective of the regulatory government body during pipeline construction is to ensure that disturbed soil profiles are maintained so as to return chemical and physical soil properties to a condition consistent with the pre-disturbance state. If the above is accomplished, then and only then is equivalent soil capability achievable.

Several examples of soil handling procedures or modifications to these procedures were presented as alternatives to achieve the above-stated objective. These examples included:

1. Normal two-phase.
2. Three-phase - Option A.
3. Three-phase - Option B.
4. Three-phase Soil Handling for Grasslands.

Illustrations of each procedure, as well as its limitations and potential modifications were presented.

In conclusion, it is the Regulatory Agency's position that considering physical and chemical soil limitations and various eco-regions in the province, to reclaim disturbed soil profiles and maintain equivalent soil capability:

1. There are soil handling procedures which have been successfully implemented to achieve the required objective of equivalent soil capability.
2. It is necessary to retain three-lift as a soil handling procedure alternative.
3. Qualified and continuous field inspection is required to implement required and approved soil handling procedures. This inspectional obligation is also required to "further define" areas designated for three-lift.
4. Suitable contractor equipment to meet the approved soil handling procedures is essential (i.e., trench width).

In conclusion, from the experience obtained in the past year or better, it is my conclusion that good progress has been made to maintain soil capability in situations where

adverse physical and chemical soil properties in subsoil materials exist. There are modifications to present procedures that are available to achieve even better results, and, with continued cooperation between government and industry, everyone's goal of soil conservation can become a reality.

A detailed outline of Mr. Onciul's presentation is included in Appendix 18.

2.6.2 Industry Perspective

Mr. Mike Houser, Environmental Construction Specialist, NOVA Corporation of Alberta, made the presentation for industry.

2.6.2.1 Introduction. The two-lift concept was developed in the mid-1970's. It has demonstrated benefits, and is still being refined for special situations and conditions.

There are varying opinions in industry and government as to the three-lift concept. These opinions range from a belief that there is no problem and nothing need be done; to a belief that there is a certain problem and a specific solution is required.

If there is a soils problem, three-lift is one procedure proposed to alleviate the problem, but it may not be the only procedure that will achieve the desired results. Development of any soil handling procedure is based on two sets of criteria, soil criteria and construction criteria, to arrive at a soil handling procedure.

2.6.2.2 Procedures. Several procedures were presented as illustrations of what is possible. Information was presented on when and where the procedure was applied, and the impact zones most affected.

The impact of the pipeline as a whole should be considered to ensure that pursuing the benefit of a singular objective does not increase overall impact. The procedures presented included:

1. No strip:
    a. narrow ditch
    b. plough-in.
2. Ditch line.
3. Blade width.

4. Ditch and spoil.
5. Full width.
6. Extra depth stripping.
7. Trench three-lift; nine variations.
8. Double grade three-lift; ABC.
9. Double grade three-lift BC->A; four variations.
10. Winter extra depth two/three-lift.
11. Winter three-lift for rocky subsoils.

2.6.2.3 Construction Parameters. With regard to cost, it can be 25% higher for trench three-lift to 100% higher for extra depth two/three-lift. This can vary from $5,000 to $50,000 per km of right-of-way, which is very significant.

2.6.2.4 Alternatives. Alternatives to three-lift include:

1. Narrow trench.
2. Plough-in.
3. Chemical treatment.
4. Physical treatment.
5. Overstripping.
6. Boring-drilling.
7. Patience - expanded management time frame.
8. New procedures and equipment when the situation is clarified.

2.6.2.5 Conclusion. At the present time there are few answers, and many questions. Industry does know that the increased time, effort and cost of three-lift justify a serious benefit analysis. The three-lift analysis as it stands is not ready for routine application.

A complete outline of Mr. Houser's presentation is included in Appendix 19.

2.6.3 Questions

Questions on soil handling methods centred around several issues, including:

1. The goal of minimum disturbance versus the increased disturbance required for three-lift, and the economics involved.
2. The areas of the province where three-lift will be required.
3. Consideration of other environmental risks in choosing to use three-lift.
4. The similarity in end goals desired by industry and government; and that several questions need to be answered in order to bring a resolution of the two positions.
5. The possibility of landowners demanding three-lift if it is considered a state-of-the-art procedure.

Discussion detail is outlined in Appendix 20.

3. SUMMARY OF WORKING GROUP PRESENTATIONS

3.1 WORKING GROUP DISCUSSION POINTS

1. What soil handling/conditioning alternatives exist to resolve concerns addressed by the three-lift procedure?
2. Comments on interim criteria for use of three-lift procedures.
3. Terms of reference for developing research proposal(s) to assess the effectiveness of three-lift soil handling: (a) goals; (b) measurement parameters; and (c) field design.
4. Discussion of definitions.

3.2 PRESENTATION POINTS - WORKING GROUP 1

The group initially prioritized the discussion points and allocated time to each. This group decided not to discuss the definitions. They worked towards achieving consensus within the group.

3.2.1 Interim Guidelines

The general opinion of the group was that the Interim Guidelines should be thrown out. They need modification. Criteria for the procedure are needed.

Three-lift is only one alternative that should be considered.

Some modifiers to the criteria should be considered. Considerations such as land use, length of area affected, depth, thickness, bedrock texture should all go into an overall rating.

It was recommended that a "map unit" be used rather than a "soil unit" or series.

It was noted that 15 cm is outlined as a minimum depth for three-lifting. Should there also be a maximum?

This group leaned towards using the 1985 criteria, with a sliding scale.

3.2.2 Alternatives to Three-lift

The alternatives suggested included:

1. In gravel, two-lift but screen gravel.

2. Treating sodic subsoil.
3. Overstripping.
4. Boring.
5. Two/three-lift.
6. All pipelines above ground.

Economics would be considered in choosing an alternative.

3.2.3 Research

Research undertaken should be designed to meet a goal. The group thought the goal should be to determine if there is a significant difference in two-lift/three-lift in maintaining capability. They suggested the following research plan:

1. Conduct a survey of existing pipelines since 1980 (assume these were two-lifted).
2. Set up a monitoring program for new pipelines to gather data on approved or alternate handling procedures. A database could be developed, and this information could be used to develop guidelines. Monitoring of new lines could be a condition of approval for a line, and a company could be required to monitor two to three lines per year. There is a need to develop standard monitoring procedures. More information is needed on how installation on a particular line was done.
3. Evaluate criteria based on research and some material to be gathered.
4. Evaluate the impact of modifiers on the criteria.

Some other issues need to be addressed, including:

1. Definitions "what is suitable", and "time capability factor".
2. Sampling procedures.
3. Identification of soil series that must be three-lifted, or where alternative soil handling practices must be used.
4. Application of chemical means of altering saline/sodic materials.

A detailed outline of group discussion and a list of participants is included in Appendix 21.

3.3 PRESENTATION POINTS - WORKING GROUP 2

The group addressed definitions, guidelines, research, and alternatives.

3.3.1 Definitions

The group debated productivity/capability for about one hour. The term equivalent capability was also addressed.

Productivity/Capability. These two measurements are related to each other.

Disturbance. Three-lift soil handling is not independent of disturbance.

3.3.2 Interim Guidelines

There are five main needs:

1. Where - need to determine soil properties for which two-lift soil handling will not suffice.
2. Length - the soil map unit is an appropriate unit to use.
3. Depth - regarding the A horizon; need to look at specifying a depth to provide a satisfactory buffer (group had no definite suggestion). For the B horizon, need to set a minimum and maximum depth. Need to set a depth limit for lift depth and minimum sample depth.
4. Materials handling - identify optimal procedures to minimize total impact.
5. When - winter/summer possibilities.

3.3.3 Research Needs

The following research needs were identified:

1. Use existing information (i.e., mining information) and tie it in to what is going to be done as long as it is relevant.
2. Develop a pipeline database. The database would incorporate information from as-built reports, and pure research on topics such as:
   a. productivity versus capability,
   b. depth to poor quality,
   c. depth of replacement (B material minimum/maximum removals),
   d. overstripping,

e. amendments,

f. disturbance width,

g. B/C mix ratios,

h. identify locations of problem soils,

i. develop equipment to address new requirements.

3. Develop a focused monitoring program.

3.3.4 Alternatives to Three-lift

The following alternatives to three-lift were identified by the group:

1. Overstripping.
2. Management over time with and without amendments.
3. Incorporation of B/C mix.
4. Equipment considerations (i.e., fit trench diameter to pipe diameter; use correct equipment for the job; other alternatives).
5. Removal of rocks before backfill.

A detailed outline of group discussion and a list of participants is included in Appendix 22.

3.4 PRESENTATION POINTS - WORKING GROUP 3

3.4.1 Interim Guidelines

Four major concerns were identified.

Criteria Concerns. There was concern that the class boundaries are arbitrary (especially considering small changes involved), and that there was no consideration of the relative importance of the parameters.

The system needs to consider all aspects of soil capability, and the degree of change (e.g., consider "ecoclimatic" factors, landscape, hydrology etc.). Is application of soil series appropriate? The relative importance of these factors should be considered.

Site Inspection. The 50% should apply to a soil unit, not the number of sampling locations. Using number of sampling locations leaves a lot to surveyor judgement. (It should be noted that the 50% is considered arbitrary.)

15 cm Depth. This is an arbitrary number. It may be considered a soil limitation as well as an equipment limitation. It is perhaps more a function of Part 1 of the Criteria. The point was raised that equipment limitations are a separate issue.

Unit Length Minimum. This should be reviewed and adapted. It is arbitrary. The question was raised as to whether it is appropriate.

3.4.2 Research

Several research projects were proposed:

1. Determine the effect of mixing various proportions of subsoil horizons on the resulting quality of the profile. There is a need for sampling and testing methodology.
2. Assess/inventory lines in place to investigate the time effect, and the relative influence of the parameters. There was a question on the validity of this, and as an alternative the following was suggested.
3. As-built follow-up monitoring regarding the time effect. The method of comparison must be clarified.
4. Time sampling needs to be investigated. There is a need to clarify the conditions of sampling, evaluate predictability and variability of results.

3.4.3 Alternatives

The group acknowledges the potential for use of alternatives. These include:

1. Re-routing.
2. Boring.
3. Narrow ditch.
4. Ploughing.
5. Overstripping.
6. Amelioration.
7. Cultural (vegetative cover).

3.4.4 Questions

Government Regarding the 50% and surveyor's input, if he says that 50% needs to be three-lifted, would you three-lift the whole unit, or just 50%?

Industry We wanted to get away from the idea of using a percentage of a sample to determine whether three-lift is required. The percentage makeup of the unit should be used, and therefore if more than 50% of the unit is indicated to need three-lift, then the whole unit would be three-lifted.

A detailed outline of group discussion and a list of participants is included in Appendix 23.

3.5 PRESENTATION POINTS - WORKING GROUP 4

As a general comment, the cost/benefit of the policies must be addressed. Soil is more than the sum of its pH, E.C. etc. We must work with the ecology.

3.5.1 Definitions

This group indicated that the scope of the workshop was inappropriately limiting. Items such as economics and extent of disturbance cannot be excluded from the discussion. A cost-benefit type analysis should be undertaken.

The group addressed some of the definitions, and suggested some minor changes. As for the term "Capability", it was suggested that a concise definition is required by both government and industry; this could not be arrived at by the group. The group sees soil as greater than the sum of its components. "Soil Quality" needs to address soil in the landscape.

3.5.2 Soil Handling Alternatives

Overstripping was mentioned as a possibility. Routes could be selected to avoid three-lift areas. Depth of burial is a consideration; there are limitations due to safety. Chemical amendments are a possibility.

3.5.3 Interim Guidelines

All parties recognize the need for improvement, and given that common view, there is hope for a consensus being reached.

The approach is considered inappropriate. There is a need to flag undesirables. There is too much subjectivity (but that was also mentioned as a good property of the guideline). Several needs were identified:

1. There is a need for a system to predict the capability of the mixed subsoil layers, and to test the model.
2. The model doesn't account for geographic or topographic variability.
3. Sampling needs to address soil variability and timing constraints of the industry.
4. The thickness of the second lift needs to be addressed.
5. There is confusion on the status and implementation of the guideline within the department.

3.5.4 Research Needs

Numerous research needs were identified including:

1. Exploration of equipment improvements including soil handling hardware, and ploughing equipment (investigate maximum diameter).
2. Investigate the possibility of using chemical amendments to control B/C mixing problems.
3. As-built reports are similar to NEB reports, and information from these sources could be combined to form a database.
4. Establish a database (similar to the ideas identified by the first two groups) to handle the monitoring information.
5. Quality control in inspection and implementation of soil management practices.

A detailed outline of group discussion and a list of participants is included in Appendix 24.

3.6 PRESENTATION POINTS - WORKING GROUP 5

3.6.1 Definitions

Definitions were mentioned, but were not addressed.

3.6.2 Alternatives to Three-lift

The group felt that all the alternatives have merit. These include:

1. Winter construction on fragile soils.
2. Overstripping.
3. Ploughing in (can use two to three passes to alleviate compaction).
4. Amendments (but keep in mind, moisture is required for percolation to get rid of amendment byproduct).
5. Use snow fences to catch moisture to aid percolation.
6. Landfarming of surplus soil to reduce crown and improve moisture.
7. Leave ditch depressed to catch moisture, but be careful to avoid water erosion.

3.6.3 Interim Guidelines

The following comments were made on the Interim Guidelines:

1. Can industry do a more detailed soil survey if there is concern about the three-lift requirement?
2. It is important to avoid a discharge area when sampling?
3. Boundaries of the capability classes are not suitable. It was suggested that a range of change from the initial be set as the criteria. This range concept needs development.
4. Present criteria are suitable for gravel and bedrock, but not for salt.
5. There is a need to review the three-lift criteria. The group suggested three different approaches to doing this: combined industry/independent consultants/government; industry makes a presentation to government; independent consultants develop the criteria. The group did not come to consensus on the approach to be used.

6. The above described work should be done from now to March '91, as work on regulated pipelines will be minimal until that time.
7. The criteria must consider tradeoffs and land use.

3.6.4 Research Needs

The group set a goal for research needs identified. This was to determine whether three-lift improves capability over two-lift.

It was also indicated that productivity is a legitimate measure on pipelines. When using productivity, a range of crops must be considered, and the inputs on the subject site must be the same as on the control.

Specific projects identified included:

1. Study of salt - movement, moisture required, and time frame.
2. Investigate whether extra disturbance outweighs the benefits of three-lift. Consideration should be given to a number of different climatic areas and different soil areas.
3. A study of 10 to 12 sites over three to four years comparing three-lift sites to two-lift sites. Should consider salt movement, economics, surface disturbance, productivity, energy inputs, erosion potential, percolation, and compaction etc. The study could include existing pipelines which were two-lifted, but would now be three-lifted to look at the results.
4. A study of land farming of excess spoil.
5. A study of appropriate organic matter content for overstripping.
6. A study of appropriate trench width (i.e., how narrow can the trench be and still get proper flow and backfill).

3.6.5 Questions

Industry Please explain your comment on land farming of excess spoil.

Consultant This would require a landowner agreement. Need research into how thin it would have to be spread so there would not be a negative effect. Ideally it

would be spread off the right-of-way on the subject property, otherwise economics could be prohibitive.

A detailed outline of group discussion and a list of participants is included in Appendix 25.

3.7 SUMMARY - WORKING GROUP PRESENTATIONS

The main points presented by the working groups under each of the headings are outlined below.

Soil Handling Alternatives. It is generally accepted that three-lift or an alternative to two-lift is required in some cases. Several soil handling alternatives were identified to resolve concerns addressed by the three-lift procedure. All of the alternatives were thought to have merit, but research may be needed in some cases to assess applicability to specific situations. The main alternatives identified included:

1. Plough-in.
2. Narrow ditch/minimum disturbance.
3. Boring.
4. Two/three-lift for winter.
5. Overstripping.
6. Management over time (cultural, with and without amendments).
7. Incorporation of B/C mix.
8. Landfarming of excess spoil.
9. Amelioration.

Interim Criteria. Both industry and government want clear criteria for materials handling decisions. The general opinion was that the Interim Guidelines need to be modified. The main areas of concern are outlined below.

1. Modifiers for the criteria should include considerations such as land use, length of area affected, depth, thickness, soil properties, bedrock texture, geography, and topography. At present, the class boundaries are arbitrary, and no consideration is given to the relative importance of the parameters.

2. Regarding the lift thickness, it was suggested that there may be a need for a minimum and a maximum thickness for the B horizon, and a specified depth to buffer the A horizon.
3. There was support for criteria using a sliding scale, similar to that used in the 1985 draft criteria. Boundaries of the current soil quality classes were not considered suitable.
4. It was suggested that the soil map unit is an appropriate handling unit to use.
5. The criteria "50% of the site inspections" should be altered to be "50% of the soil map unit", and the 50% is considered to be arbitrary. ("Site inspections" leaves a great deal to surveyor discretion.) Sampling must address soil variability.
6. The criteria could include a caveat that industry has the option of doing a detailed soil survey if a preliminary survey indicated the three-lift procedure was required.
7. The criteria as presented may be appropriate for gravel and bedrock, but need revision for saline/sodic soils.

Research Proposals. It was indicated that research should be co-funded by industry and government. The research program should be designed to meet a goal. The goal identified was to determine whether there was a significant difference between two-lift and three-lift in maintaining capability. The following research needs were identified:

1. Any existing information that is applicable should be accessed (i.e., mining data, as-built reports); in addition, a survey of existing pipelines (since 1980) could be undertaken to gather information such as the effect of time, and the relative influence of the parameters.
2. A monitoring program should be set up for new pipelines to gather data on approved and alternate handling procedures. A database of this information should be developed, and would provide a basis for refinement of the guidelines. Monitoring of the lines could be a condition of approval for the lines (on a limited number of lines per year per company). A

standard sampling/monitoring procedure would be required to assure comparability of data.

3. A monitoring study of 10 to 12 sites over three to four years, or as required, comparing three-lift sites and pre-disturbance conditions.
4. Additional pure research is needed to address topics such as productivity versus capability, depth to poor quality materials, use of amendments, B/C mix ratios, salt movement and time frame, additional disturbance versus three-lift benefits, equipment requirements, etc. Standard sampling and testing methodology would be required to address these needs.
5. After the detailed research is completed, the criteria should be evaluated and revised as necessary.

Definitions. Only some of the groups discussed the definitions in any detail. It was generally agreed that the definitions need to be revised, and that agreement on the definitions can be reached. Review of the definitions should be referred to a working group such as the Three-lift Task Force.

The closing comments for the second day gave a good overview of the workshop. It was indicated by both government and industry that increased trust between the two groups must be encouraged. There was a need to present the positions of the two groups, and this workshop allowed that to happen. What is needed now is continued communication between the two groups. There was open communication at the workshop and progress was made. Many issues and points that need to be addressed were identified, as outlined above. These points must be addressed, with input by some combination of government/industry/private consultants, so that further progress can be made.

4. CLOSING COMMENTS

4.1 INDUSTRY COMMENTS

Mr. Ian Scott, Senior Coordinator - Pipeline Division, CPA, provided closing comments for industry.

There was some trepidation at the beginning of the workshop, but there has been a lot of interest shown. The key element is communication between industry/ government/companies and individuals, and the workshop has helped to enhance communication.

This forum is not the end of the process. We need to work on the Interim Criteria, and definitions. There are information gaps which need to be filled.

Industry recognizes the three-lift process may be appropriate in some situations, but alternatives should also be explored. Industry wants a consultative process, and is willing to fund research where needed.

What we need now is to build trust and look forward. This will come through communication. The next step will be a major step for both industry and government.

4.2 GOVERNMENT COMMENTS

Mr. John King, Director, Land Reclamation Division, Alberta Environment, provided closing comments for government.

The degree of cooperation and communication that occurred in the workshop is illustrated by the fact that my comments parallel those of Ian Scott.

There was a need for both sides to present their positions; that was the reason for the workshop. Progress has been made, and further discussion groups could result in more progress.

Suggestions made will be taken forward to the Alberta Pipeline Environment Steering Committee. The Task Force may also do some work, research items may be directed through RRTAC or the Task Force. Hopefully industry and government can move forward together from this point.

APPENDICES

5. OPENING REMARKS - JOHN KING[1]

Welcome to everyone here.

This workshop provides an excellent opportunity for us to communicate on significant issues. Our main goal is to move towards a common ground.

One of the major topics to be addressed is chemical quality of the soil medium. Three-lift is one approach to dealing with this. The Alberta Pipeline Environment Steering Committee was formed to address issues such as this. The committee has identified up to twenty-five issues. Task Forces will be created to address some of these issues, and a Three-lift Task Force is one of these.

I'd just like to mention the government contribution to the workshop. Through RRTAC (Reclamation Research Technical Advisory Committee), we have provided a facilitator for the workshop, Mr. Don Hoover of Deloitte & Touche.

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[1] Director, Land Reclamation Division, Alberta Environment.

6. OPENING REMARKS - IAN SCOTT[2]

Welcome to everyone.

Industry's involvement in the workshop included providing the lunches for the two days courtesy of IPAC (Independent Petroleum Association of Canada) and CPA (Canadian Petroleum Association), and the CPA coordinated the organization of the event.

The object of the workshop is to obtain knowledgeable input into the appropriateness of the two-lift and three-lift processes.

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[2] Senior Coordinator - Pipeline Division, Canadian Petroleum Association.

7. DEFINITIONS AND SCOPE OF WORKSHOP - DEFINITIONS PROPOSED BY GOVERNMENT - CHRIS POWTER[3]

The success of this workshop will depend on all of us using the same terminology and working from the same starting position. Therefore, the following points will help set the stage for our discussions. They are not cast in stone, and can be debated, but before any other discussions take place, these points must be agreed upon.

D&R Pipelines. This workshop is focusing on D&R pipelines.

Disturbance. Land will be disturbed by pipeline activities. The workshop is not to address the issue of minimal disturbance, which is the subject of other discussions.

Economics. The workshop is focusing on return of environmental quality (equivalent capability) following disturbance, not the cost of meeting agreed upon standards.

Extent of Disturbance. The width of disturbance is determined by a variety of factors, including soil handling methods, trench depth and trench width. The area to be disturbed is: mapped to determine pre-disturbance conditions; reclaimed; and, security is released and land eventually certified based on the pre-disturbance conditions. The condition of the area surrounding the disturbance is irrelevant to this process.

Three-lift. This is a term given to a procedure for selectively handling soil below the topsoil in separate lifts or layers. The term implies that one or more identifiable layers or **Horizons** of the soil below the topsoil are "better" than others, and that, upon selective handling and replacement, these layers will provide a better rootzone than if the soil was not selectively handled. It recognizes the proportionally greater value of the upper subsoil than the lower subsoil for root development and plant growth. The term also implies that the soil layers can be identified by sampling and analysis of specific parameters, and that such sampling must be conducted for all soil layers to trench depth.

Soil Types for Three-lift. There are generally two types of soils where selective handling would be warranted: those with physical conditions that may hinder reclamation, e.g., excessive stoniness; and those where chemistry is of concern, e.g., saline soils.

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[3] Chairman, Reclamation Research Technical Advisory Committee.

Two-lift. The term implies that all soil below the topsoil is similar (or not different enough to warrant selective handling) and that it can be handled in such a fashion as to ensure the return of a suitable rootzone.

Comparisons. We are not interested in comparing three-lift (selective handling) to two-lift or vice versa. We must compare three-lift (or two-lift) to pre-disturbance conditions.

Correct Procedures. Any materials handling procedure must be done well in order to meet the expectations placed on it. Thus, three-lift done poorly is not three-lift.

Topsoil Replacement. All topsoil will be conserved and replaced. This is a given and should not be used as a rationale for two-lift in the context of this workshop.

Subsoil. The key soil issue in the context of this workshop is the initial and final quality of the subsoil materials and how this is seen as affecting both short- and long-term capability of the disturbed soil.

Return of Security. The security deposit is returned when all the conditions of the approved D&R have been met. Land disturbances are certified when all the conditions of the approved D&R have been met and the pipeline has been decommissioned. It is therefore critical that all parties agree on the conditions and measurement standards set out in the D&R plan.

Capability. The ability of the soil to sustain an approved land use is affected by both chemical and physical properties of that soil, and is called the capability of that soil. Return of capability is the desired reclamation goal, and is intimately associated with the term **Soil Conservation** defined below. Changes to the absolute values of the chemical and physical parameters that determine capability may occur, but must be within acceptable ranges. For the purposes of pipeline reclamation, **Soil Capability** is evaluated, since pipelining does not change landscape form. For larger disturbances such as coal mines, **Land Capability** is evaluated since it takes into account potential changes in landscape form. The document Land Capability Classification for Arable Agriculture in Alberta (1987) is a good reference for the capability issue.

Soil Quality. The quality of the various soil layers is judged through the use of the ratings in the document Soil Quality Criteria Relative to Disturbance and Reclamation (see p. 24 and 25). It is this document that is used by Alberta Environment staff in determining whether three-lift is required. A more commonly used term for soil quality is **Soil Suitability**.

The quality or suitability rating given to a particular soil or soil horizon is an estimate of its value as a substrate for sustaining plant growth.

Productivity. All conservation and reclamation objectives of the Department are based on capability. Productivity is not considered when evaluating success of reclamation, however a visual assessment of the vegetation may be used as an indicator of capability. Vegetative cover, vigour and density are important in so far as they ensure erosion control, since erosion can adversely affect soil capability. Species composition, especially the type and density of weedy species, is a concern in agricultural lands and must be addressed by the company to the satisfaction of the Reclamation Officer, landowner and the local District Agriculturalist.

Soil Conservation. Soil conservation is the combination of all methods of management and land use that will protect the soil against physical loss or depletion, and chemical deterioration by natural and man-influenced factors. For the purposes of this workshop, these measures are taken in the planning and materials handling stages of the operation. **Reclamation** occurs after a disturbance and is an attempt to remediate a problem created by the operation. Wherever possible, conservation is to be practised so that reclamation requirements are minimized.

Soil Survey. A soil survey is conducted to provide government and industry with a field guide and map for planning soil handling procedures. The methodology for the soil surveys required for pipelines is specified in the document "Information Requirements for Regulated Pipelines".

8. DEFINITIONS AND SCOPE OF WORKSHOP - INDUSTRY COMMENTS ON "DEFINITIONS AND SCOPE OF WORKSHOP" FROM C. POWTER, NOVEMBER 15, 1990

Disturbance. "... is not to address minimal disturbance, ...". This is an unreasonable limitation as width/extent of impact is part of the three-lift argument.

Economics.

1. Costs are relevant to industry.
2. Is equivalent capability defined as return of environmental quality?

Extent of Disturbance. The logic of this discussion is difficult to follow. Land is certified based on pre-disturbance conditions?

Three-lift. The soil is handled in three lifts; 1) topsoil, 2) upper subsoil, and 3) lower subsoil (which is of undesirable quality). If you want to use "Rootzone", please define.

Soil Types for Three-lift. (suggested this definition) Soils Types that Require Alternate Procedures.

There are two general soil conditions that warrant alternate construction procedures:

1. Soils with undesirable upper subsoil overlying gravel or coarse sand lower subsoil.
2. Soils with desirable upper subsoil overlying weathered bedrock (soft mudstone or shale) that has very undesirable characteristics.

Two-lift. No implications. The soil is handled in two lifts: 1) topsoil, and 2) subsoil.

Comparisons. We need to compare two-lift to three-lift from a cost/benefit point of view.

Correct Procedures.

1. This discredits most soil handling activities.
2. If "two-lift" done poorly, not "two-lift"?

Topsoil Replacement.

1. "... all topsoil conserved and replaced ..."

2. This means to narrow ditching unless stripped - conflict with Public Lands. (Minimal disturbance concept.)
3. Comments re rationale for two-lift is not understood.

Subsoil. "Key soil issue is quality of subsoil" and how it affects short- and long-term capability.

1. Key issue is protection of the topsoil (growing medium). Change of subsoil properties directly below topsoil may influence overall soil quality.
2. We must wrestle with the questions of how we rate the effect of subsoil properties on the overall soil quality (capability), and the issues of short- and long-term.

Return of Security. D&R's for pipelines are construction and short-term reclamation documents. They do not contain specific measurement standards for final reclamation.

Capability. The generally accepted definition of capability is "a rating of the performance of a land unit for a particular use or group of uses". Capability focuses on the nature and degree of limitations imposed by the biophysical characteristics of a land unit on a certain use. (Refer to Canada Land Inventory guideline reports.)

Soil Quality. Quality is the correct term, use of the term suitability is incorrect.

Note: The "Soil Quality Criteria" book does not provide definitions - nor does it describe how to determine post-construction soil quality, and therefore whether three-lift is required. The criteria were intended for rating soil materials for use as reclamation materials.

Suitability. An index of performance of a land unit which compares outputs from the land with the required inputs and associated environmental conditions for a specified land use and production system.

Note: The statement "for the purposes of pipeline reclamation soil capability is evaluated" is not true. Soil quality is evaluated.

Productivity. Productivity is an index of performance of a land unit, as are capability and suitability and is used by Reclamation Officers.

Soil Conservation. Conservation should be practised when economically feasible to do so, so that Reclamation requirements are minimized.

Soil Survey. May be worthwhile to expand on this definition.

General.

1. Alternate handling methods for soils with undesirable subsoil layers should be on the table, and might be a better title for the entire workshop.
2. Still no explanation of how to measure equal (equivalent?) capability, and this is important for everyone to understand and agree upon at the start of this workshop.
3. The reason for the workshop and scope should be more clearly set out at the beginning of the presentation.

9.	DEFINITIONS AND SCOPE OF WORKSHOP - QUESTIONS
Industry	Please answer the question of "What soil is for?"
Government	Soil may be used for a number of things, including plant growth. We don't want to prejudge soil use and its management for best productivity. We want to create a medium which will be used for a suitable area use. In pipeline situations this is generally back to the previous use. We want to return it to the closest state to its previous capability.
Industry	Let's not get into "we" versus "you".
Consultant	I'm surprised that productivity is not to be addressed. What will grow in soil is a good indicator of the capability of the soil. Productivity is a critical factor.
Government	Productivity is, to a great degree, a result of management. We must return soil to as close to its previous state as possible and then the same plants will grow, even if more intensive management is not applied.
Consultant	Can we discuss productivity?
Government	Productivity is not the only assessment tool to evaluate soil capability.

10. OVERVIEW OF GOVERNMENT AND INDUSTRY POSITIONS - GOVERNMENT POSITION - JOHN KING[4]

The concern we have is with soil capability. The government wants to prevent soil deterioration relating to pipeline activity.

The Government of Alberta Mission Statement sets out the government's objectives as they relate to the environment. One of the main principles of the Statement is that the government will use research and leading edge technology in the development of conservation and reclamation standards.

Reclamation is an integral part of operations, but we should preplan it where possible. Land is a sustaining element of the environment to be available for future generations.

We need to clarify some terms - conservation/reclamation/restoration/ preservation. What we are doing is not preservation; that would imply leaving it exactly the same as it was. We need to practice reclamation (getting materials back and stabilizing the disturbance), and conservation (minimizing the impact).

The term "equivalent capability" is defined as "returning the soil to as close to its pre-disturbance potential as possible". It also involves the ability of land to support various uses such as agriculture, forestry, wildlife and recreation on a sustained basis.

Government is not stuck on the idea of three-lift. Other ideas might work successfully. We do know that three-lift done properly does work; and that three-lift done improperly does not work. We must address the chemical quality of the subsoil in the growth medium below the topsoil. How this is accomplished is open to discussion. Alternatives are available.

We need to compare three-lift to the pre-disturbance capability; two-lift to the pre-disturbance capability, not three-lift to two-lift.

This three-lift discussion is not new. The question came back because some larger lines have again been put in. There may not be too many of these in the future, but we want to come to a common ground so a position has been developed when the question arises.

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[4] Director, Land Reclamation Division, Alberta Environment.

For 1990 there were 1,259 applications, 60 of which were D&R pipelines. Fifteen of these, or 25%, were three-lifted to some degree. This accounted for only about 4% of the length of these D&R lines.

If sodic material ends up at the surface and wasn't there naturally, it affects capability. There is a question about whether such a situation can be certified, and the security deposit returned.

Government sees three-lift as one approach that will work and therefore, is buying into it. If new information becomes available in the future to show otherwise, then the position will have to be re-addressed.

Government wants industry to agree with the regulations. The object is not just for the company to meet the requirements of the owner (which may be too great or too little), but also to meet the requirements of government. Sometimes the companies want to do more or less, therefore the requirements are needed.

We are moving to a more scientific approach. We will continue to move this way, and need collective action towards this.

The Interim Three-lift Guidelines were developed. From a regulators point of view they have speeded up the application process, and have increased the soil information coming in with the application.

We need to define and understand the three-lift procedure. It must be done properly to succeed. We have research on the effect of sodic material on capability and productivity. The results have been confirmed by field observation. Application of the Soil Quality Criteria Document confirms the potential for loss of soil capability.

I strongly support the process we are going through here. Government's objective is to achieve proper environmental protection of our soil resource - this is what the public expects of us.

After the workshop, the proceedings will feed back to the Steering Committee and the Task Force and RRTAC. A summary report will be presented to APESC on December 20.

11. OVERVIEW OF GOVERNMENT AND INDUSTRY POSITIONS - CPA/IPAC POSITION - BOB SEAGER[5]

Regarding a previous question: There is some necessity to take positions. We need to get some understanding of the polarization of opinion on the issues, but the intent is to come to a common understanding.

Industry's position was developed through meetings of CPA and IPAC members, with the assistance of Len Knapik of Pedocan.

11.1 GUIDING PRINCIPLES

As stated in the CPA Environmental Code of Practice, industry is committed to the policy of protecting the environment. The industry will assess the potential effects of their projects and will integrate protective measures into the planning process to prevent or reduce impacts upon the environment.

With regard to environmental protection during pipeline construction, the industry is willing to use procedures that are practical and are seen to result in a demonstrated benefit to the environment.

Industry is committed to changing construction and operation practices where it is demonstrated there is a knowledge-based need to change.

Industry is committed to support research relevant to improving industry's ability to protect the environment (innovative procedures/pilot projects).

Industry is committed to working with government when they are developing laws, regulations and guidelines.

Industry would like to see a clearly defined philosophy and stated standards of soil reclamation. Pipeline construction necessarily results in some changes in soil properties. (Acceptable limits of change should be defined.)

Industry sees two-lift soil handling to be the accepted procedure. Before three-lift is accepted as a procedure the benefits of it must be clearly demonstrated.

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[5] Supervisor of Environmental Protection - Construction, NOVA Corporation of Alberta.

Pipelining is not similar to strip mining. Experience from the coal mining industry cannot be used to develop regulations for the pipelining industry.

11.2 ASSESSMENT OF NEED TO CHANGE SOIL HANDLING PRACTICES

The following concerns and questions have been raised with regard to soils with undesirable subsoil layers.

Where is the documentation of impacts resulting from normal construction practice on these soils?

1. What is the extent of the problem?
2. What type of impacts result?
3. How severe are the impacts?
4. How persistent are the impacts?
5. What methods of mitigation are successful?

Available research results indicate many saline-sodic pipeline soils are self-reclaiming over a time period as short as two to three years.

Alternate construction practices (narrow ditch, plough-in, boring, three-lift, overstripping, physical or chemical mitigation) can be used to avoid or reduce impacts associated with undesirable subsoil layers in different ecoclimatic areas, under various types of land use. What are the trade-offs of alternate techniques?

What are the criteria for successful soil reclamation of these and other problem soils? Define through a consultative process, the post-construction soil quality goal, and then we can develop procedures to attain that goal.

What is the implication of three-lifting certain soils in terms of cost per unit length of pipeline, and total cost to the industry?

11.3 INDUSTRY'S POSITION ON THREE-LIFT

Industry recognizes there are certain soils that have strongly contrasting, undesirable, subsoil layers.

Given the right set of circumstances of soil, climate, landscape position, land use and construction practice, the quality and productivity of the soil could be negatively impacted for a long period of time by pipeline construction. The impact could be mitigated

by various methods, including alternate construction procedures. Appropriate construction practices might include three-lift, plough-in, narrow ditch, boring, or two-lift with amelioration.

There are two general soil types that warrant alternate construction procedures:

1. Soils with desirable upper subsoil overlying gravel or coarse sand lower subsoil.
2. Soils with desirable upper subsoil overlying weathered bedrock (soft mudstone or shale) that has very undesirable characteristics.

There is a third general soil type that may warrant alternate construction practices:

1. Soils with desirable upper subsoil overlying subsoil that is strongly saline, is strongly sodic, or is strongly saline-sodic. The position of the soil in the landscape, the ecoclimate, and the land use must be considered in addition to soil profile data in determining the appropriate construction practice.

The "interim criteria for evaluating three-lift" (Alberta Environment, August 22, 1990) are inappropriate and should be withdrawn.

Appropriate criteria for identifying soils with strongly contrasting, undesirable subsoil layers should be developed. A first approximation of these criteria is attached in Section 11.4 (modified from Alberta Environment 1985).

An appropriate procedure for predicting post-construction soil quality from pre-disturbance data are required.

Appropriate post-construction soil quality standards are required.

The criteria for identifying soils, the predictions of soil quality, and the post-construction standards should all be applied to every soil series in Alberta to develop a "Soil Reclamation Planning Data Base" which would include recommended practices (see Section 11.5 for example).

A process of soil monitoring after construction could provide feedback on appropriateness of construction and mitigation techniques. Results could be used to modify standard recommendations.

Soil reclamation planning in the D&R Application process should rely largely on recommended practices by soil series (with room for exceptions). The correct practices by soil series could be agreed to periodically, outside of the approval process.

Industry is willing to participate in a properly designed research project to determine the negative and positive impacts and costs of alternate practices.

Industry is willing to participate in research to develop new techniques (not necessarily three-lift) to minimize soil impacts.

11.4 1985 GUIDELINES - UNDESIRABLE SUBSOIL CRITERIA

Property	Desirable Material (2nd lift)	Undesirable Material (3rd lift)
Electrical Conductivity (E.C.)	≤ 5 5 to 10 > 10	at least 4 units higher at least 6 units higher N.A.
Sodium Adsorption Ratio[a] (SAR)	< 8 8 to 12 > 12	at least 6 units higher at least 8 units higher N.A.
Saturation Percentage[b]	--	at least 40% higher than desirable material
Stone Content (% Vol)	< 3 3 to 25 25 to 50	> 25 > 50 N.A.

[a] SAR criteria apply only to materials that are loam to heavy clay in texture. Criteria may be altered by the presence of high levels of either lime or gypsum in excess of other soluble salts.

[b] Saturation percentage criteria apply only to weathered bedrock materials.

N/A Not Applicable - multiple lift of the subsoil is not required.

The criteria for sodicity (SAR) may be altered by the presence of high levels of lime ($CaCO_3$) or gypsum ($CaSO_4$) in excess of other soluble salts. Calcareous and especially gypsiferous soil materials are useful in improving sodic soil materials.

Saline seepage areas often have better quality materials at depth (higher E.C. or SAR values in the upper material relative to the lower material). Separate removal of materials in such areas is not recommended.

11.5 USE OF SOIL SERIES FOR PLANNING

Soil Mapping and Soil Names. Soil mapping is the identification, description and delineation on a map of different types of soil, based on direct field observations or on indirect inferences from such sources as aerial photographs. The soils found within a survey area are arranged into a limited number of types on the basis of properties that are relevant to the survey objectives. Each major type of soil will be described and sampled in sufficient detail to allow accurate soil classification and reliable evaluation of soil performance. For reference purposes, major soils are given names. Soil map units are established to describe the portions of the real landscape that are associated in a regular and repetitive fashion with each type of soil. The map units are differentiated not only by their component soils, but also by external features of the landscape such as slope and rockiness. Soils and soil map units are related to the other factors of their environment, notably to climate, landforms and vegetation. The locations of the map units are shown on the map by delineations and symbols. The map unit symbol within each delineation identifies the soil and its map unit. Each symbol is listed in the map legend, which gives brief descriptions of the soils and their map units, and forms a link between the map and report.

Soil Series. A soil series is a particular soil profile, developed in a particular geological material, within a particular climatic area. In Alberta, soil map units are usually named after their dominant soil series. The soil series name is taken from a local geographic feature (e.g., Ponoka, Beaverhill), and provides a short code to refer to a long list of associated attributes, including:

1. The types and thickness of horizons.
2. Texture, salinity, sodicity, pH and other attributes.
3. The type(s) of geological material the soil is formed in; stoniness; depth to bedrock.
4. The local ecoclimate.
5. Expected crop yields and net productivity data.

6. Capability ratings for various land uses.
7. Normal depth to watertable.
8. Erosion risk ratings.
9. Many other derived interpretations.

Soil series are usually defined in terms of "typical" profile descriptions and associated test data. Descriptive statistics (mean, range, maximum) of data are gradually being developed.

The agricultural land assessment system in Alberta is based on net productivity ratings by soil series. The Canada Land Inventory, Soil Capability for Agriculture Maps of Alberta were developed using the concept of rating soil series.

11.6 CONCLUDING STATEMENTS

Industry favours a consultative, scientific approach to development and implementation of all new guidelines and regulations.

Industry favours development of guidelines outside of the application approval process (e.g., develop standard soil handling prescriptions by soil series which can be used to streamline the approval process).

It is appropriate for government to identify areas where further work is needed to reduce environmental impacts and to not allow development if the impacts cannot be reduced to an acceptable level. It is inappropriate for government to unilaterally specify techniques to be used, as industry may have or may develop other more cost effective alternatives which have the same or more benefit to the environment as the one specified by government.

It is essential to keep soil capability and productivity issues in perspective. Pipeline companies operate pipelines for many years after construction and other remedies are or will be available during this period which may be more effective (in reducing environmental impacts) in the long run than utilizing costly, marginally effective techniques during construction.

Industry recommends that government and industry work together to develop practical and effective guidelines and efficient approval processes so that benefits to the environment can be maximized.

Pipelining will always have some impact on the environment, therefore, it is important for industry and government to work together such that an orderly development of energy resources will occur in a timely and cost effective manner, yet be done such that the environmental impacts are acceptable.

12.	OVERVIEW OF GOVERNMENT AND INDUSTRY POSITIONS - QUESTIONS
Government	How divergent/united are the positions within industry, and within government?
Industry	At the first meeting of the CPA and IPAC there was a major discussion of the first draft and quite divergent opinions. At the next meeting, we moved on to a more structured agenda, and more progress was made towards a consistent position. Some of the differences in opinion were due to the fact that some companies had been exposed to three-lift recently, and others had not.
Industry	Is capability time independent, or time dependent?
Government	In the case of productivity, management inputs can alter the situation. Capability, in some cases, can be assessed in the short run (as in the case of a growing crop), and in some cases, a much longer timeline is needed (i.e., in the case of a forest). The feeling is that when a process has been shown to maintain capability in one case, that this process should always result in maintenance of capability.
Industry	The previous question may have been somewhat vague. Does the capability of a soil (disturbed or undisturbed) change over time?
Government	That is an unfair question of me (government) in this setting. Maybe one of the (industry) experts present could address the question.
Industry	Sorry if the question was inappropriate. The idea was referenced earlier and I thought maybe government had a clear idea on this.
Consultant	A later presentation may address this topic.
Government	Referring to Item 3 - Alternative Methods, I don't see how many of these apply, except maybe overstripping. Can you expand on the applicability of these to D&R pipelines, for example, narrow ditching to a large inch pipe?
Industry	Alternative methods are relative. For a 48" line, 50" is a narrow ditch. Any size pipeline can be regulated. Some alternatives are possible only for certain sizes of pipelines; some for any size.

Consultant — I have a question relating to the wording regarding the soil types. Why the use of "procedures" for the first two types, and "practices" for the third type?

Consultant — There was not meant to be a difference. It's based on the difference between comfortable practices and theoretical procedures. For the first two soil types it is recognized that alternatives are needed; for the third type, something may by needed.

13. THREE-LIFT RATIONALE - THREE-LIFT SOIL HANDLING FOR PIPELINES IN ALBERTA - TRAVIS FERGUSON[6]

13.1 RATIONALE FOR THREE-LIFT

Soil Conservation Versus Soil Reclamation. Alberta Environment focuses on conservation for two basic reasons: (1) soil conservation now, reduces reclamation efforts later and, (2) without proper preplanning, damage to the soil could be irreversible.

The Alberta Government views reclamation as an integral part of industry's ongoing operations, and insists it be preplanned.

Wise use of our environment implies conservation as an important factor governing the use of resources.

Maintenance of the Entire Soil Profile. Alberta Environment considers the entire soil profile when evaluating soils for materials handling. The topsoil horizon is critical to crop production. Subsoil provides the root medium essential to sustainable agriculture. Topsoil and subsoil are two soil components that directly affect soil capability.

Where soil horizons on the lands to be disturbed are sufficiently well developed to support plant growth, or in the opinion of the approving authority to be capable of supporting plant growth, the soil horizons should be selectively removed in the manner prescribed by the approving authority.

The operator should use all soil and surficial materials suitable for reclamation to form the reclamation in the manner prescribed by the approving authority.

The operator shall handle surficial materials in a manner that ensures a rootzone that is capable of supporting sustained plant growth where required for future use.

Maintenance of Soil Capability. A primary focus of Alberta Environment is conservation. Maintenance of soil capability infers conservation.

13.2 DEFINITIONS/BACKGROUND

Soil Productivity. The capacity of a soil, in its normal environment, to produce a specified plant or sequence of plants under a specified system of management.

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[6] Soil Scientist, Land Reclamation Division, Alberta Environment.

Productivity means the capacity of soil to produce crops and is expressed in terms of yields.

Soil Conservation. Protection of the soil against physical loss by erosion or against chemical deterioration (that is, excessive loss of fertility by either natural or artificial means).

A combination of all methods of management and land use that safeguard the soil against depletion or deterioration by natural or man influenced factors.

Control Section. 0 to 100 cm is used as the control section as it represents the effective rooting zone for most annual crops. (Pettapiece 1987)

In the case of mineral soils, the control section generally involves a depth of 1 to 2 m. (Soil Quality Criteria Working Group 1987)

The control section for pipelines is evaluated to trench depth. Material suitability and soil quality must be considered for all horizons to trench depth. Generally, maximum trench depth for oil and gas pipelines is between 1 and 2 m, thus the control section for pipelines is generally 1 to 2 m.

Soil Classification. Soil is usually composed of three horizons (A, B, C): A - mineral horizon found at or near the surface generally characterized by a zone of leaching or an accumulation of organic matter; B - mineral horizon characterized by enrichment in organic matter, clay, sesquioxides or by the development of structure or a change in colour; and, C - unaltered or slightly altered parent geologic material.

Soil Survey. Objectives are to provide information on the types of soils present in sufficient detail that decisions regarding materials handling and post-disturbance reclamation can be made.

Soil Unit. Soil units are conceptual descriptions of repeating landscape patterns in which names of individual kinds of soils (soil series) are used to describe and predict the classes of soil within the soil unit and the likely properties associated with those classes. (MacMillan 1987)

Soil Map Unit. A combination of kinds of soil, or miscellaneous land types that can be shown at the scale of mapping for the defined purpose and objective of a particular soil survey. (MacMillan 1987)

Detailed soils information is required for all regulated pipelines built in the White Zone of Alberta. This soil information is gathered using a soil survey. Soils are described at the series level of soil classification. These soil series are presented on a pipeline alignment sheet as soil map units. The minimum size of the map units reflect the intensity of the soil survey.

13.3 LAND CAPABILITY CLASSIFICATION FOR ARABLE AGRICULTURE IN ALBERTA

This system was designed to replace the old C.L.I. rating system. The system is composed of 7 classes and 21 subclasses. These classes and subclasses define and quantify limitations expressed in the three main components (climate, landscape and soil).

Agricultural Land Capability Classes. A grouping of lands that have the same degree of limitations or hazard for agriculture. The degree of limitation or hazard becomes progressively greater from class one to class seven.

Normally land capability is rated on the basis of three components including soils, climate and landscape. However, the process of rating pre- and post-pipeline construction considers only the soil component because climate and landscape are unaltered and thus considered constant.

Land Capability = f (Soils, Climate, Landscape).

Considering pipeline construction

Land Capability = f (Soils).

Factors for Mineral Soils. The Land Capability Classification system recognizes two types of soils: (1) mineral soils and, (2) organic soils. Organic soils are generally not arable and thus are not conducive to three-lift soil handling. Mineral soils only need to be evaluated.

Mineral soils are divided into two zones: (1) surface zone 0 to 20 cm; and (2) subsurface zone 20 to 100 cm.

Because salvage of the surface zone (topsoil) is required in all cases, it is generally only necessary to evaluate the quality of the subsurface zone (20 to 100 cm) for three-lift soil handling determination.

Subsurface Zone. Average of five factors: (texture, structure and consistence, depth to nonconforming layers, acidity, and salinity and sodicity).

These factors are considered as modifiers to the surface rating and thus are managed as percentage reductions of the primary surface rating.

We do not presently use this rating system. Land capability changes identified in the field are not reflected as a land capability change using this system. The percentage reductions in the subsurface layer are not identified by depth. For example, the system recognizes a similar deduction for high salinity at 20 cm and high salinity at 100 cm. Principles of soil science and crop productivity suggest that under these circumstances a soil capability rating change should occur. Each of the five factors should be progressively more limiting at shallower depths.

13.4 SOIL QUALITY CRITERIA RELATIVE TO DISTURBANCE AND RECLAMATION - 1987

Purpose of this document is to provide criteria for material quality assessment prior to disturbance and subsequent to reclamation with the goal of minimizing environmental impact that occurs as a result of land disturbances.

General Guidelines. Occurrence and depth of master horizons (A, B, C) in the pre-disturbance state have a bearing or influence on how materials are salvaged, with respect to the different lifts involved and subsequently the manner of replacement.

Replaced soil thickness should be no more limiting to plant growth than it was in the undisturbed state.

Individual areas of disturbance have unique characteristics, problems and special requirements, therefore, materials handling techniques and soil replacement will be site specific.

This system is related to soil capability in that with selective materials handling, the goal of maintaining soil capability will be achieved.

This system recognizes the most limiting soil property as the overall rating.

13.5 THREE-LIFT SOIL HANDLING CRITERIA

The following are interim criteria used to evaluate three-lift soil handling procedures for pipeline construction in Alberta.

1. The predicted post construction soil rating of two-lift handled soils is at least one soil suitability class less than three-lift handled soils. (Soil Quality Criteria Relative to Disturbance and Reclamation 1987)
2. At least 50% of site inspections within a soil unit must demonstrate the need for three-lift soil handling (as per #1 above) before it is required.
3. The second lift thickness is at least 15 cm.
4. Soil handling unit length is the equivalent of one soil map unit delineated at the series level of soil classification.

Detailed Analysis of Criteria.

1. Soil Rating System. The Soil Quality Criteria document, specifically material suitability requirements, were chosen as text to evaluate material for three-lift applicability for the following reasons:
   a. This is a published, widely used document developed by a working group composed of government and industry.
   b. This document was developed to consider all types of surface disturbances and subsequent reclamation.
   c. This document considers the soil properties that could have a bearing on overall soil capability.
   d. This document characterizes soil properties into material suitability classes that can be used to determine soil handling requirements.
2. Soil Unit Site Inspections. Site inspections are used by soil surveyors to confirm the presence of a specific type of soil. Site inspections are thus representative of soils found in a soil unit. The dominant soil found in a particular map unit is used to evaluate the soil handling procedure for that map unit.

   Soils are mapped and described on a site specific basis at a predetermined intensity level. Thus for a particular project, similar soils (soil series) should have similar materials handling procedures.

   The minimum 50% criteria was developed in an attempt to discern a reasonable materials handling procedure for a specific soil unit.

3. Minimum 15 cm Second Lift. The minimum 15 cm second lift thickness was initiated for two reasons:
   a. Present day materials handling equipment can consistently and accurately salvage a 15 cm second lift of soil.
   b. Soil capability may not be affected when the second lift thickness is less than 15 cm.
4. Soil Handling Unit Length. In regulated pipeline construction, soils information is collected at a soil survey intensity level one to three. (Information Requirements for Regulated Pipeline 1988)
   Using the predetermined soil survey intensity level and other factors identified during the survey, soil map unit boundaries are delineated. Soil delineations and boundaries separate dissimilar soils (different soil map units). The minimum size of these soil map units correspond to the minimum soil handling unit length.

13.6 PROBLEM SOILS FOR THREE-LIFT

Two main types of soils require separate handling of major soil horizons to maintain soil capability:

1. Physical properties - gravel at depth.
2. Chemical properties - salinity and/or sodicity at depth.

Gravel at Depth. In areas where gravel can occur within the pipeline trench, gravel should be replaced at pre-construction depths. Any gravel replaced closer to the surface following material replacement could cause a soil capability reduction.

Gravel can be found in any area of the province. Gravel at depth is normally associated with fast moving water, primarily fluvial and glaciofluvial deposits. Ferintosh and Scollard soils are developed on these deposits and are candidates for three-lift soil handling.

Salinity and/or Sodicity at Depth. Salinity and sodicity may require three-lift soil handling when they exist below a non-saline/non-sodic subsoil layer. To prevent a loss in soil capability, the saline and/or sodic region should be replaced at pre-construction depths.

Salinity and sodicity can be found almost anywhere within the White Zone of the province. Salinity and sodicity are generally associated with ground water discharge areas and shallow marine bedrock.

13.7 EXAMPLE OF A THREE-LIFT SOIL

The following is an example of a soil that could require three-lift soil handling.

This saline Chernozem occurred on a pipeline near the town of Daysland, Alberta. The soil has been mapped as a saline Elnora (Chernozemic soil with a saline/sodic C horizon).

This soil is subject to three-lift soils handling for the following reasons:

1. The Csk horizon is one soil suitability class less than the Bm horizon.
2. With this example there is only one site inspection and this site inspection demonstrates the need for three-lift.
3. The second lift thickness is 44 cm (greater than 15 cm thick).
4. The complete soil map unit requires three-lift soils handling.

An error was made in the presentation. Only pre-disturbance soils are evaluated for three-lift soil handling using the material suitability criteria discussed in the Soil Quality Criteria Relative to Disturbance and Reclamation. Considering the information provided there does not exist a rating system to accurately predict soil quality changes following a pipeline disturbance.

For demonstration purposes only, a reconstructed soil profile can be estimated to identify potential soil property changes. The saline Elnora soil described in Table 1 shows an increase in pH, E.C., SAR and Sat% in the 16 to 60 cm zone following mixing of the Bm and Csk horizon. An increase in these soil properties could have a negative effect on soil capability.

Table 1. Saline Chernozem (Saline Elnora)

Horizon/Depth (cm)		pH	E.C.	SAR	SAT%	Overall Texture	Rating
Bm	16 to 60	6.8(G)	2.8(G)	5.2(F)	37(G)	CL(F)	Fair
Csk	60 to 120	7.9(F)	7.6(P)	12.8(U)	39(G)	CL(F)	Unsuitable
Considering Two-lift Soil Handling							
Horizon/Depth (cm)		**pH**	**E.C.**	**SAR**	**SAT%**	**Overall Texture**	**Rating**
Spoil	16 to 120	7.4(G)	5.6(P)	9.6(P)	38(G)	CL(F)	Poor

13.8 EXAMPLE OF A TWO-LIFT SOIL

Soils do not require separate handling of horizons when the degree of limitation for each horizon is similar (within the same soil suitability rating).

A Solonetzic soil may not require three-lift because the degree of limitation in the Bnt horizon is similar to the degree of limitation in the C horizon. The Bnt horizon could rate as unsuitable due to SAR and the C horizon may rate unsuitable due to E.C.

13.9 SUMMARY AND CONCLUSIONS

Soil conservation is a primary goal of Alberta Environment. Wise use of our environment implies conservation as an important factor governing the use of resources to ensure our quality of life is sustained for future generations. Alberta Environment also stresses that environmental protection requires anticipation and prevention. The Alberta Government requires land to be reclaimed following development activity. Reclamation is an integral part of industries ongoing operations; Alberta Environment insists it be preplanned.

Alberta Environment recognizes that not all of our past protection efforts have been successful. To improve on these problems, Alberta Environment uses research and

leading edge technology in the development of conservation and reclamation standards. Three-lift soil handling is one alternative to achieve our construction and reclamation goals.

14. THREE-LIFT RATIONALE - QUESTIONS

Industry I have a few comments. Topsoil is a primary resource. I'm not clear on subsoil qualification as a resource. It's a question of the depth of the control section.

Most annual crops don't use 100 cm, therefore, what is the rationale for using 100 cm?

I question the soil capability definition. Does this change over time?

Extrapolation of soil units is an art, not a science. They are not easily delineated.

Regarding land use prediction; I believe we do know what it will be.

Regarding class boundaries for soil quality criteria, there were four, the same as for coal mines; then it was changed to two; now we're back to three classes (1987).

It appears that, based on various scales, qualifications such as "poor" could be altered; a small unit change in a parameter may result in dropping a class.

Government In the past, only topsoil has been considered as a resource and was stripped. Soil scientists agree that subsoil is also a resource.

Regarding the 100 cm; in the land classification document, 100 cm is used as a control section. The agricultural document by Pettapiece relates mainly to cereal crop production.

Time is obviously a function in soil formation. We don't know the number of years - be it two, four, or five - which would be appropriate.

On the comment that land use will not be known, it generally will be known, although we cannot definitively state it.

On the question of soil quality, there was an '83 and an '87 document; the '85 document was a draft report, an internal document.

Industry The '85 draft dealt with floating units, not strict ranges.

Government If the limits changed (between the '83 and '87 documents), it was not significant. There are fine lines inherent in the classification systems. Where there are set limits, a person must use flexibility. Comments on the

	document came in asking for both stricter and lesser criteria. The guidelines are an overall perspective, accepted by soil scientists throughout the world.
Industry	I don't agree with that.
Government	The guidelines related to strip mines, but also apply to other disturbance situations.
Industry	On the chart for saline Elnora (Appendix 13.7, Table 1) how did you arrive at the data on two-lift soil handling?
Government	It's a weighted average.
Consultant	pH is a log function, and cannot be averaged. You could go back to the original Na, Ca and Mg, or could batch samples as mixed soil and then analyze them. If SAR and E.C. are the basis of the decision, this is fundamental.
Consultant	I support this comment, there is no basis for averaging to obtain these results.
Government	E.C. is mobile, but we see field data that do not support this. The data show that areas where this occurs are dry, and salts will not leach.
Consultant	E.C. is mobile, and a time factor must be considered. An average could be used, but I don't totally support the averaging idea for E.C. either.
Government	In the second part of the table (Appendix 13.7, Table 1), were volumes considered?
Consultant	I just want to clarify, I didn't produce the data at the bottom of the table; only the top.
Government	In the second part of the table, a straight average was used.
Industry	How is the tradeoff made between minimum soil disturbance and the three-lift issue?
Government	Three-lift results in more disturbance, but area disturbance is a different parameter from the three-lift issue. There will be a trade-off consideration on evaluation.
Industry	Is there no scientific basis, only a judgement call?

Government	We need to look at cover, and revegetation requirements. We may need to consider alternatives.
Industry	In the case of gravel, is texture used as a criteria, and for salinity and sodicity use E.C. and SAR? Please clarify if you are basing three-lift on selected parameters or properties.
Government	For gravel, yes, texture is used. The table gives equal weight to all factors. There could be a requirement for the three-lift procedure based on only one criteria depending on the extent of the problem. The land capability document (Land Capability Classification for Arable Agriculture in Alberta) puts a weighting on each characteristic. It is a subjective decision, and the criteria table isn't followed exactly, but knowledge must be applied to each decision.
Industry	You mention subjectivity on what has been thought to be an absolute table. The previous method offered a sliding scale. Was this not a better procedure?
Government	I agree, the '85 system could be good, but the great variability within the unit (1985) created a weakness in that system.
Industry	How long can we accept disturbance for? The guidelines were intended for the whole province. The relative difference in the northeast versus other areas may not be well understood. Regarding time, we are not worried about the next three years, it's a somewhat subjective assessment.
Government	Alberta Environment won't accept long-term losses in capability, but there has been no definite definition of short-term/long-term.
Industry	We need more definite parameters.
Consultant	Regarding the mobility of salts - some respond quickly; some don't. It relates to water and soil structure at the site. There are lots of areas of subjectivity. We could have surveyors quantify everything, but that would escalate pipeline survey costs. We need parameters for reasonable guidelines, keeping in mind costs and time requirements etc. We need to know how much judgement of a pedologist is allowable.
Government	I would agree.

Government	I have a question on the requirement for evaluation of the two-lift/three-lift approaches. You showed two cases for Elnora soils - two-lift and three-lift. This goes against an idea previously presented that a soil series could always be handled in the same way.
Government	We must use the wisdom of the surveyor, and field interpretation. There is a lot of variability in the field. There is a need for a general soil handling procedure for certain soil series (e.g., saline), with exceptions based on the surveyors findings.
Industry	I have a concern on the #1 criteria. It focuses on salinity and sodicity.
Government	These are problems focused on in the past.
Industry	Who's subjectivity do we rely on - the soil surveyor, Alberta Environment? What criteria do we use - E.C., SAR - and at what levels? I have a problem with this.
Government	This has been developed based on a consensus of industry/government/ consultants on how to best handle that soil. We want to get back to using land capability. It is finite and provides guidelines.
Consultant	I can't see the economic justification for three-lift in a pH situation. It's not economically feasible to base three-lift on parameters that can be controlled. I don't agree with how the conclusion is arrived at.
Government	I agree, pH has not to date been used. The variability in soil far exceeds the averaging done. Field data can be selective.
Consultant	If the variability is that great in the field, there is a need to rethink the problem.
Government	Yes, we have had many areas resurveyed for just this reason.

15. FIELD DATA TO SUPPORT POSITIONS - AN EVALUATION OF TWO-TIERED SOILS IN ALBERTA FOR THREE-LIFT HANDLING - ARNOLD JANZ[7]

15.1 ABSTRACT

Soils in Alberta for which the three-lift handling procedure is considered necessary for soil conservation are characterized by two-tiered profiles in which the upper subsoil is distinctly different and of significantly better quality than the lower subsoil. Separate handling of these two subsoils is essential to prevent degradation of topsoil and upper rootzone materials.

Seven main types of two-tiered soils have been identified in Alberta. All seven have relatively favourable upper subsoils overlying unfavourable lower subsoils. Three types have chemical limitations and four types have physical limitations for reclamation in the lower subsoil.

Geographically, two-tiered soils with favourable upper subsoils overlying unfavourable lower subsoils, are estimated to be of relatively small areal extent. Those with chemical limitations (saline-sodic lower subsoils) are generally confined to localized areas where soloneztic soils are dominant while those with physical limitations (such as gravelly or clayey subsoils) may occur in localized areas throughout the province.

15.2 RATIONALE FOR THREE-LIFT HANDLING

15.2.1 Soil Conservation

Because of the relatively short history of oil and gas development in Alberta, long-term (many decades) impacts of oilfield and pipeline development on soil resources have not been adequately evaluated nor understood. Soil handling procedures have, in the past, been largely developed on the basis of construction convenience and short term (several years) visually observable effects on single component systems rather than on the basis of continuous long-term effects on multiple components (ecosystem approach). Visually observable negative effects have generally been assessed as being "topsoil" related

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[7] Soil Specialist, Land Conservation and Reclamation Council, Alberta Environment.

rather than "whole-soil" (profile) related. On the basis of field experience and soil conservation principles, it has become evident that the "topsoil" approach to soil conservation must be replaced by the "whole-soil" approach if soil capability is to be maintained for the long term.

Soil conservation has been defined as follows: "the combination of all methods of management and land use that will protect the soil against physical loss or depletion, and chemical deterioration by natural and man-influenced factors" (from "Soils of Canada" glossary). This principle recognizes the inherent value of a soil as a whole and in its parts, regardless of its geographic location, landscape position, land use or economic contribution.

The principle also recognizes the following:

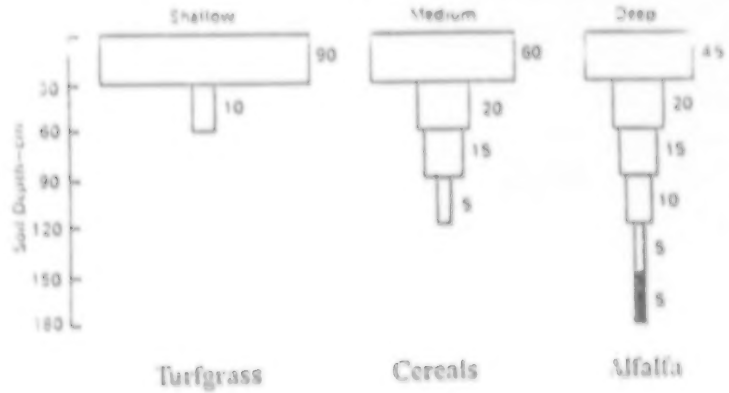
1. The extent of the soil resource is limited.
2. The extent of the soil resource is diminishing.
3. Soils are sensitive, easily damaged and difficult to repair.
4. The long-term effects of development are not well known.
5. The soil resource is an integral component of the ecosystem.
6. Soils in different locations and landscape positions should not necessarily be handled alike.
7. Soil resources must be conserved for future generations.

The acceptance of the soil conservation principle has several significant implications for soil management including:

1. Conservation of the quality and characteristics of the whole-soil and its components is required.
2. Conservation must be preplanned on the basis of whole-soil and component quality.
3. Conservation procedures should be preplanned and accompany development stages of the operation rather than rely on reclamation or repair procedures after operation completion.
4. Conservation efforts for each soil zone (horizon) must be proportional to the value of that zone as a root medium for all crop types suitable for the region (Figure 2). As an example, for cereal crops with an effective rooting depth of 120 cm, approximately 80% of roots occupy the upper 60 cm

zone in a non-limiting soil. For alfalfa with an effective rooting depth of 180 cm, approximately 65% of the roots occupy the upper 60 cm depth zone. In both crop types, approximately 20% of the roots occupy the 30 to 60 cm depth zone (upper subsoil) in a non-limiting soil. It follows that any physical or chemical degradation of the 30 to 60 cm depth zone will potentially have a negative impact on the effective rooting depth and ultimately growth and productivity.

Figure 2. Generalized Pattern of the Effective Rooting Depth of Various Crop Plants



Source: Hausenbuiller, 1985.

15.2.2 Specific Research

(Battle River Soil Reconstruction Project - Subsoil Depth Experiment). The Battle River Soil Reconstruction Project is located in east-central Alberta. It has been established to evaluate soil quality and crop productivity after mine reclamation. The initial till subsoil materials used were rated as "Fair" to "Poor" for reclamation because of chemical (salinity, sodicity) limitations. The five year results indicate:

1. Cereal roots are generally confined to the upper 30 cm of the reconstructed soil.
2. Root growth is governed by the rootzone environment, including moisture and nutrient supply, aeration, root penetration resistance and chemical toxicity.

3. The reclaimed subsoil (rated "Fair" to "Poor") appears to be unsuitable for cereals.
4. Overall subsoil quality (physical and chemical) remains relatively unchanged.

Although it may be inappropriate to directly apply all the findings of this project to pipeline situations, principles which apply to long-term soil behaviour are similar. Observations that overall subsoil quality remains relatively unchanged over the short term (5 years) should be applicable to other disturbances in the area. This has been confirmed through observations by Alberta Environment on wellsites and pipelines where original subsoil conditions remain relatively unaltered for 15 to 20 years after site reclamation.

15.2.3 General Research

It is well known from general salinity research and experience that crop tolerance to saline soil conditions varies widely. Cereal crops are moderately tolerant while flax, canola, peas and beans are more sensitive to salinity within the rootzone (Table 2). It follows that any significant upward change in salinity in the midsoil zone would begin to negatively affect sensitive crops. In situations whe e the lower soil tier is significantly more saline than the upper tier, soil degradation caused by salinity increases in the rootzone can be expected, especially when the upper tier is not handled separately from the lower tier.

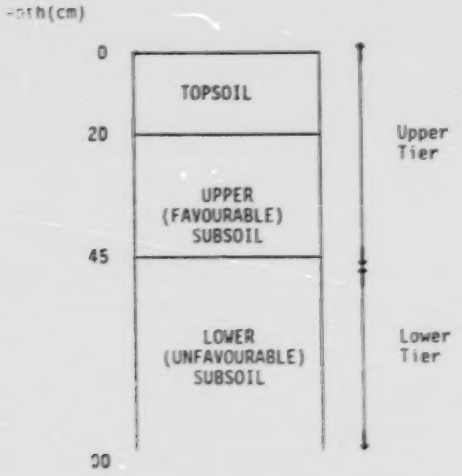
Table 2. The Relative Productivity of Crops With Increasing Salt Content in the Rootzone

Crop	Relative Productivity, % at Selected EC (dS/m)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Flax	100	96	84	72	60	48	36	24	12	0	0	0	0	0
Alfalfa	100	100	93	85	78	71	64	56	49	42	34	27	20	12
Wheat	100	100	100	100	100	100	93	86	79	71	64	57	50	43
Barley	100	100	100	100	100	100	100	100	95	90	85	80	75	70
Source: Carter, 1981														

15.3 DESCRIPTION OF POTENTIAL THREE-LIFT SOILS

Potential three-lift soils are those which, in their undisturbed state, have three distinctly different zones within the profile which have developed on at least two different geologic materials (an upper and a lower tier). Three distinct zones include topsoil, midsoil (upper subsoil) and lower subsoil (Figure 3). Topsoil and midsoil zones generally occur in the upper geologic tier and the lower subsoil has developed in the lower tier. Two examples are provided in Tables 3 and 4.

Figure 3. Generalized Cross Section of a Typical Three-lift Soil Profile



15.3.1 Characteristics

The characteristics of each geologic and soil zone are described as follows:

1. Upper Tier - This tier usually contains the favourable topsoil and midsoil materials. It is generally less than 1 m thick, stone-free, contains some organic matter, is coarser textured than the lower subsoil, brown in colour, and non-saline and non-sodic. Contact between upper and lower tiers is often abrupt. During salvage, topsoil and midsoil should be separated because of the relatively high value of topsoil as a seedbed and rootzone material on the surface following replacement.

Table 3. Potential Three-lift Soils With Chemical Limitations in the Lower Tier (Sheerness Area)

Tier	Depth (cm)	Material	pH	E.C.	SAR	Texture[1]
Upper	0 to 15	Topsoil (Eolian)	ND	ND	ND	L
	15 to 30	Favourable	5.7	0.3	1.6	SL
	30 to 40	Subsoil (Eolian)	6.7	3.1	6.1	SL
Lower	40 to 50	Unfavourable	8.0	11.2	21.7	CL
	50 to 65	Subsoil (Till)	8.5	14.4	22.3	CL
	65 to 100		8.4	17.0	25.0	CL

Table 4. Potential Three-lift Soil With Physical Limitations in the Lower Tier (Berry Creek Area)

Tier	Depth (cm)	Material	pH	E.C.	SAR	Texture[1]
Upper	0 to 20	Topsoil (Eolian)	6.5	0.22	0.3	SL
	20 to 50	Favourable	6.7	0.16	0.3	LS
	50 to 65	Subsoil (Eolian)	7.0	0.12	0.3	LS
Lower	65+	Unfavourable Subsoil (Outwash)	ND	ND	ND	G

[1] L - Loam
CL - Clay Loam
G - Gravel
SL - Sandy Loam
LS - Loamy Sand
ND - No Data

Both topsoil and midsoil materials are significantly more favourable for use as rootzone materials than the lower subsoil (lower tier).

2. Lower Tier - This material occurs in the lower part of the soil profile under the upper tier at any depth below approximately 25 cm. It is generally of unfavour-able quality for reclamation relative to the upper tier. It may be composed of one of several different materials including gravel (glacio fluvial outwash), clay (lacustrine), clay loam till, rock (bedrock), sandstone or mudstone (residual). Till, lacustrine and residual materials may be saline and sodic.

15.3.2 Classification

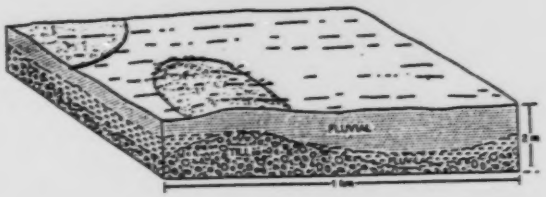
Seven different potential three-lift soil types have been identified in Table 5 and illustrated in Figure 4. They are differentiated on the basis of geologic origin and quality for reclamation. Types 1, 2 and 3 are differentiated on the basis of chemical limitations in the lower tier, while Types 4 to 7 are differentiated on the basis of physical limitations in the lower tier.

Table 5. Description of Potential Three-lift Soil Types[8]

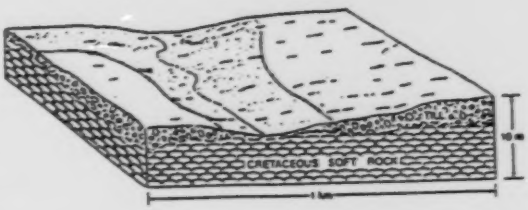
Type	Usual Parent Materials and Their Textures		Dominant Limitation of Lower Tier
	Upper Tier	Lower Tier	
1	Fluvial-Lacustrine (L-SL) or Eolian (SL-LS) Overlay	Till (CL) Till (CL)	Salinity, Sodicity, Texture
2	Fluvial-Lacustrine (L-SL) or Eolian (SL-LS) Overlay	Lacustrine (C) Lacustrine (C)	Salinity, Sodicity, Texture
3	Till (CL) Overlay	Residual	Salinity, Sodicity
4	Fluvial-Lacustrine (L-SL) or Eolian (SL-LS) Overlay	Lacustrine (C) or Till (CL)	Texture (Clay)
5	Fluvial-Lacustrine (L-SL) or Eolian Deep Overlay	Outwash (gravel) or Stony Till	Texture (Gravel, Stones)
6	Fluvial-Lacustrine (L-SL) or Eolian Shallow Overlay	Outwash (gravel)	Texture (Gravel, Stones)
7	Till (L-CL) Overlay	Bedrock (lithic)	Texture (Rock)

[8] Preliminary estimate.

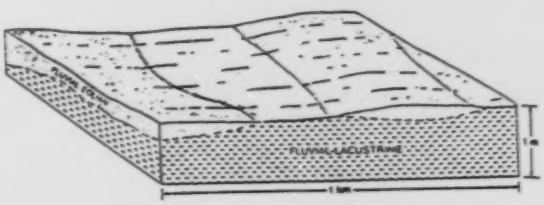
Figure 4. Cross-Sections of Typical Three-lift Material Sequences (Adapted From "Soil Survey of the County of Newell, Alberta" 1983). Three-lift areas are shaded.



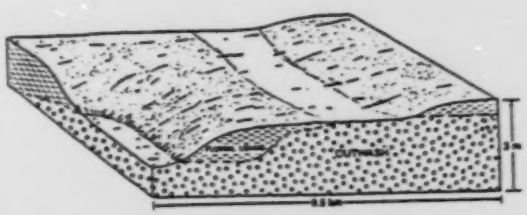
TYPE 1



TYPES 3 AND 7



TYPES 2 AND 4



TYPES 5 AND 6

15.4 IMPACT ASSESSMENT OF THE TWO-LIFT PROCEDURE ON POTENTIAL THREE-LIFT SOILS

15.4.1 Factors to Consider

An estimate of the effects of a specific two-lift operation is essential in order to determine if three-lift is necessary (Table 6). This should be an important component of the developer's planning process. Impact estimates must consider the following:

1. The short term effects.
2. The long term effects.
3. The effects across the entire right-of-way including work, trench and spoil areas.
4. The effects on the topsoil.
5. The effects on the midsoil.
6. The combined effects on the whole-soil.

Table 6. Potential Degradation Effects of the Two-lift Procedure on Three-lift Candidate Soils[9]

Parameters	Material Type						
	1	2	3	4	5	6	7
Suitability Rating	R	R	R	R	R	R	R
Upper Root Zone Texture	Finer	Finer	?	Finer	Coarser	Coarser	Coarser
Porosity and Infiltration	R	R	R	R	I	I	I
Droughtiness	I	I	I	I	I	I	I
Salinity	I	I	I	NC	NC	NC	NC
Sodicity	I	I	I	NC	NC	NC	NC
Management Effort	I	I	I	I	I	I	I
R = Reduced		I = Increased		NC = No Change			

[9] These are estimated effects based on preliminary observations and expected soil behaviour.

15.4.2 Accuracy of the Assessment

The accuracy of the impact assessment process is dependent on several important aspects of development procedures including:

1. Width of excavation.
2. Depth of excavation.
3. Degree of material bulking.
4. Type of excavation equipment.
5. Lower subsoil characteristics and thickness.
6. Midsoil characteristics and thickness.
7. Topsoil thickness.
8. Soil moisture conditions during materials handling.
9. Sampling intensity.

The planning process should incorporate as much of this information as possible in the impact assessment for three-lift determination.

15.4.3 Estimated Effects on Topsoil

It is estimated that risks of topsoil degradation will be increased significantly in situations where two-lift ("topsoil" conservation approach) procedures are selected in place of three-lift ("whole-soil" conservation approach) procedures. Risk of degradation will be higher in areas with shallow replaced topsoil, or an elevated roach. In these situations, topsoil degradation could initially occur through incorporation of mixed spoil material into topsoil during topsoil replacement over spoil. Further degradation could occur through incorporation of spoil into topsoil during cultivation. Degradation or mixing would likely be most significant on the elevated roach where shallow topsoil replacement depths exist as a result of poor replacement procedures and downslope removal over time by erosion and cultivation influences.

Specific short and long-term degradation effects have not been intensively investigated to date, however, some observations indicate that topsoil has been degraded through loss of organic matter and increased salinity and sodicity in the case of soils with chemical limitations, and increased gravel, clay or rock (reduced tilth) in the case of soils with physical limitations.

15.4.4 Estimated Effects on the Upper Subsoil

Where two-lift procedures are selected instead of three-lift procedures, two different types of subsoil degradation should be expected. The first is a result of the replacement of favourable materials (undisturbed favourable B) with unfavourable spoil mix directly under the topsoil, and the second is a result of spoil material stratification in areas beside the trench. The first type will influence the trench and all areas outside the trench where excess spoil is disposed of by spreading away from the trench. The second type will influence only areas beside the trench where the final soil profile will consist of topsoil over unfavourable spoil mix over favourable undisturbed subsoil (B or C horizon).

The short and long term effects of these two degradation types have not been specifically studied on pipelines and therefore are not known. However, it is expected that unfavourable characteristics of mixed spoil, whether limited chemically (salinity, sodicity) or physically (gravel, clay) and stratification of mixed spoil beside the trench, will reduce the overall capability rating by affecting water movement and availability, and root growth and distribution. In addition, management effort increases are expected.

15.5 THE GEOGRAPHIC DISTRIBUTION OF THREE-LIFT CANDIDATE SOILS

Potential three-lift soils can occur throughout Alberta. However, to date, soils which are associated with the seven potential three-lift types are largely restricted to agricultural regions within the province. Some Alberta soil series with three-lift characteristics are presented in Table 7. Types 1, 2 and 3 which are characterized by subsoils with chemical limitations, are generally confined to areas where near surface saline and sodic bedrock sediments such as the Bearpaw and Horseshoe Canyon Formations are responsible for the chemical characteristics of shallow deposits lying above them. Types 1, 2 and 3 are generally confined to localized areas on these lower tier deposits where shallow fluvial-lacustrine or aeolian materials (upper tier) have been deposited by wind and slow moving water since glaciation. The largest extent of these soils is located in east-central Alberta in a narrow band approximately 80 km in width between Vegreville and Brooks. However, it is expected that only a small portion of this area would have conditions which necessitate the three-lift procedure.

Table 7. Some Alberta Soil Series With Three-lift Characteristics

Material Type	Lower Tier Limitation	Potential Three-lift Soil Series	
1	Salinity, Sodicity (Till)	Gopher (Newell) Sunnynook (Newell) Antonio (Newell)	Fenner (Newell) Sullivan Lake (Newell) Rosebank (Paintearth)
2	Salinity, Sodicity (Lacustrine)	Rolling Hills	
3	Salinity, Sodicity (Residual)	Bigknife (Paintearth) Fenner (Paintearth) Sullivan Lake (Paintearth)	
4	Stoniness, Texture (Till, Lacustrine)	Codesa (Chip Lake) Peoria (High Prairie)	
5	Stoniness (Deep) (Outwash)	Ramillies (Newell) Highwood (Calgary)	Midnapore (Calgary) Sarcee (Calgary)
6	Stoniness (Shallow) (Outwash)	Two Hills (Two Hills) Snipe Hills (Two Hills) Bow Valley (Calgary)	
7	Rock (Bedrock)	Dunvargen (Calgary) Elbow (Calgary)	

Types 4, 5, 6 and 7 are also of limited linear extent in any area, however these localized areas could occur in a number of locations in the province. They would include all areas with lower tier physical limitations including clay, gravel, and rock. Types 4, 5 and 6 could be encountered throughout the province but Type 7 is likely confined to western Alberta in areas with shallow surficial deposits on non-saline, non-sodic bedrock.

15.6 SUMMARY

Two-tiered soils, as described in this report have unique characteristics for which special soil handling techniques are essential in order to prevent their degradation. These soils are usually easily recognized in the field through identification of one main characteristic - the presence of a favourable midsoil zone between the topsoil and unfavourable lower

subsoil. Separate handling of topsoil, midsoil and subsoil when preplanned and properly implemented, will ensure conservation of favourable midsoil quality at its preconstruction depth, and ultimately conservation of the "whole-soil".

This three-lift technique is presently utilized in Alberta and elsewhere in various industrial activities including coal mines, sand and gravel operations, site development and pipelining. Use of the three-lift technique and its applicability to certain industrial activities demonstrates the increased awareness by government and industry of the importance of the "whole-soil", the need to carefully manage and conserve soil resources, and a willingness to apply the best available technology and equipment toward soil conservation. As this trend continues, it could become incorporated as a standard operating procedure for a wide variety of industrial site development activities. Technological improvements and increased efficiencies are expected to accompany the procedure as it matures.

15.7 REFERENCES

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Hausenbuiller, R.L. 1985. Soil Science - Principles and Practices. Third Ed. Wm. C. Brown Publishers, Dubuque, Iowa 610 p.

16. FIELD DATA TO SUPPORT POSITIONS - PIPELINE CONSTRUCTION IN SOILS WITH "PROBLEM" SUBSOIL LAYERS - AN INDUSTRY PERSPECTIVE - AL FEDKENHEUER[10]

16.1 WHAT IS THE PROBLEM?

16.1.1 Quantification of Problem

According to the Energy Resources Conservation Board (ERCB), there were 201,300 km of pipeline in Alberta under ERCB jurisdiction at the end of 1989. Approximately 47,000 km have been constructed since 1983, about 91,000 km were built between 1975 and the end of 1983 and the remaining 62,000 plus were built before the end of 1975. Roughly 3% (about 6,000 km) is 18" diameter or larger pipe, 26% (about 52,000 km) is between 6" and 18" in diameter and the remaining 71% (143,000 km) is 6" or less diameter pipe.

With respect to soils problems caused by pipeline construction, the extent of problems have not been quantified to date. The question, "How many kilometres of pipelines exhibit a soils problem?" is a question which is begging to be addressed. It is also one which must be addressed to assist in setting out a problem-solving pathway and assigning priorities to various problems.

What needs to be done now, is to determine the types of problems existing on these pipelines, separating those built since the early 1980's from those built before that time. The reason for this is that the environmental consciousness in general underwent a major change somewhere in the early 1980's. In Alberta, the draft guidelines for a mine Development and Reclamation Plan were first released in December of 1977. Sometime after this, people started becoming more aware that pipelining was disturbing soil also. To obtain a more accurate assessment of how well today's techniques are working, when looking at "problems", there must be recognition and notation that techniques for soils handling have changed over since the early 80's towards better handling techniques.

There also needs to be an assessment of how severe the problems are and where they are located. Are there problems which are confined to a certain geographic area, are

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[10] Senior Specialist, Environment and Quality Management, NOVA Corporation of Alberta.

they related to a particular climatic zone (e.g., is precipitation a controlling factor) or are they confined to specific soil types? In addition, where is the impact zone? Is it the entire right-of-way, the trench, 0 to 10 cm, 40 to 60 cm, or where?

After going through this exercise we can properly address the question, "How many of these problems are due to incorrect subsoil handling procedures?" I stress the difference between incorrect subsoil handling (which is likely an implementation problem) and incorrect subsoil handling techniques (which implies a problem with the handling design). This is a very important difference which leads to two very different pathways to correct the situation.

16.1.2 Literature Review

The literature concerning pipelining and its impacts in Alberta and Saskatchewan generally does not support the view that pipelining creates extensive soils problems. In Saskatchewan, deJong and Button (1973) did not find significant difference in yields over pipelines in Chernozemic soils except for one soil on which yields were higher. They found yields on Solonetzic soils were higher over older trenches than on the undisturbed fields, presumably due to a deep ploughing effect. deJong (1980) attributed increased yields on pipeline trenches to increases in available plant nutrients and improved soil structure. Toogood (1974) reported significant increases in grain yields at 14 of 17 sites on pipeline trenches where topsoil and subsoil were mixed on Chernozemic and Solonetzic soils sampled one to ten years after construction. Naeth (1985) reported changes in soil parameters on Solonetzic soils under mixed prairie grasslands in southeastern Alberta as a result of pipeline construction, but these changes were generally not detrimental to plant growth. The factor she found of greatest importance by far, in re-establishing native grassland, was the grazing system employed during the re-establishment period.

Naeth (1986) stated, "Edaphic changes resulting from pipeline construction each have the potential to affect plant growth. Combinations of these factors tend to reduce the negative or positive effects produced by an individual factor. A damping of factor effects is further enhanced by the ability of plant species to adapt to a changed environment. Many factors are not significantly altered by the disturbance over the long-term and therefore may only be detrimental to the ecosystem over the short-term, if at all".

Landsburg (1989), reporting on a study initiated while she was employed by Alberta Environment, stated in her conclusions that "Both the Ap and spoil from the trench areas of the Dark Brown Chernozem soils were relatively unaffected by pipeline construction. The Dark Brown Solonetz soils had increased concentrations of soluble soils in both materials due to salt-enriched subsoil material being brought near the soil surface as a result of construction". In her closing conclusion she states, "Even with the increases in the soil properties monitored, the results indicated that regardless of soil type or land use, pipeline construction during good weather conditions did not significantly affect the agricultural soil quality of the A and B horizons".

16.1.3 Field Data

Information presented in this section was obtained from a NOVA research project on the Standard Lateral east of Calgary and from a monitoring project on the Battle River Section of NOVA's North Lateral Extension Loop #2.

Standard Lateral Research. This study was initiated in the Fall, 1983 in three areas designated by Alberta Environment pipeline regulatory personnel as requiring a three-lift soils handling procedure. Subsequently, NOVA decided to establish a research project to evaluate what would happen over time in these areas. In the areas designated as requiring three-lift, one-half was constructed using an approved "state-of-the art" three-lift procedure and the other one-half of each of the three areas was constructed using a conventional two-lift procedure.

The soils were Dark Browns developed on glaciolacustrine clays overlying saline-sodic till. Sample sites were located on mid-slope to lower mid-slope positions. Soil properties were subsequently monitored over the following five growing seasons. This presentation will focus on following what happened to E.C. (electrical conductivity) and SAR values in the area that was two-lifted and the adjacent off-right-of-way field soils, since these parameters represent major areas of concern.

The graphs for all three areas show similar trends, so in the interest of space and time, only the results for Study Area 1 and 2 are presented in the following pages. Also, since the concern is with the quality of the upper subsoil, only data from the 10 to 20 and 20 to 30 cm sample depths are presented.

The two graphs dealing with E.C. on the Standard Lateral show that E.C. increased from 1984 to 1985 in the disturbed samples for both depths (Figures 5 and 6). Subsequently, in Study Area 1, E.C. continually decreased until 1988 when it reached levels similar to the control soils. It should be noted that by 1986, three years after construction, the E.C. level was in the same soil suitability rating class of "Good" for the 10 to 20 cm sample and the next year E.C. was very close to the same class in the 20 to 30 cm sample. The E.C. level in Study Area 2 continued to rise from 1985 to 1986, probably in response to above-normal precipitation in 1986. Subsequently, E.C. dropped to levels very similar to off-right-of-way samples.

Examination of the graphs of SAR over the years 1984 through 1988 also show variability over time (Figures 7 and 8). SAR was not determined in 1987. Interestingly, SAR in the 10 to 20 and 20 to 30 cm depths of the disturbed trench dropped well below control soils in 1986. They have since come back to (slightly below for the 20 to 30 cm depth) control levels. In Study Area 2, SAR in the 20 to 30 cm depth exhibited the increasing trend through 1986, followed by a large decrease from 1986 levels through the 1988 sampling.

In summary, in these study soils, E.C. levels were at levels similar to those of off-right-of-way soil samples three to five years after pipeline construction in all three areas studied. SAR levels in the trench samples are also comparable to levels in control soil samples after three to five years.

Battle River Research. Data presented in the following bar graphs were obtained from sampling conducted October 1, 1990 on the Battle River section of NOVA's North Lateral Extension #2. Two sections, a south and a north section were sampled at the 0 to 20, 20 to 40 and 40 to 60 cm depths in areas designated by Alberta Environment regulatory personnel as requiring a three-lift soils handling procedure. The material had been replaced in the trench approximately two months prior to sampling (30" diameter pipe). Since there was an adjacent pipeline installed in 1976 (24" diameter pipe) and another installed in 1972 (16" diameter pipe), a sample transect included a soil sample from each pipeline trench. Pipeline construction techniques used for the 1976 and 1972 installations are not clear, however, it is clear that at best they were two-lifted. The overall depth of the trench is not clear at this time either, however, probing of the 1976 (24") pipe depth showed just over 1 m of cover and the 1972 (16") pipe revealed 80 cm of cover over the pipe. This means the

Figure 5. Standard Two-lift Results - E.C. Comparison

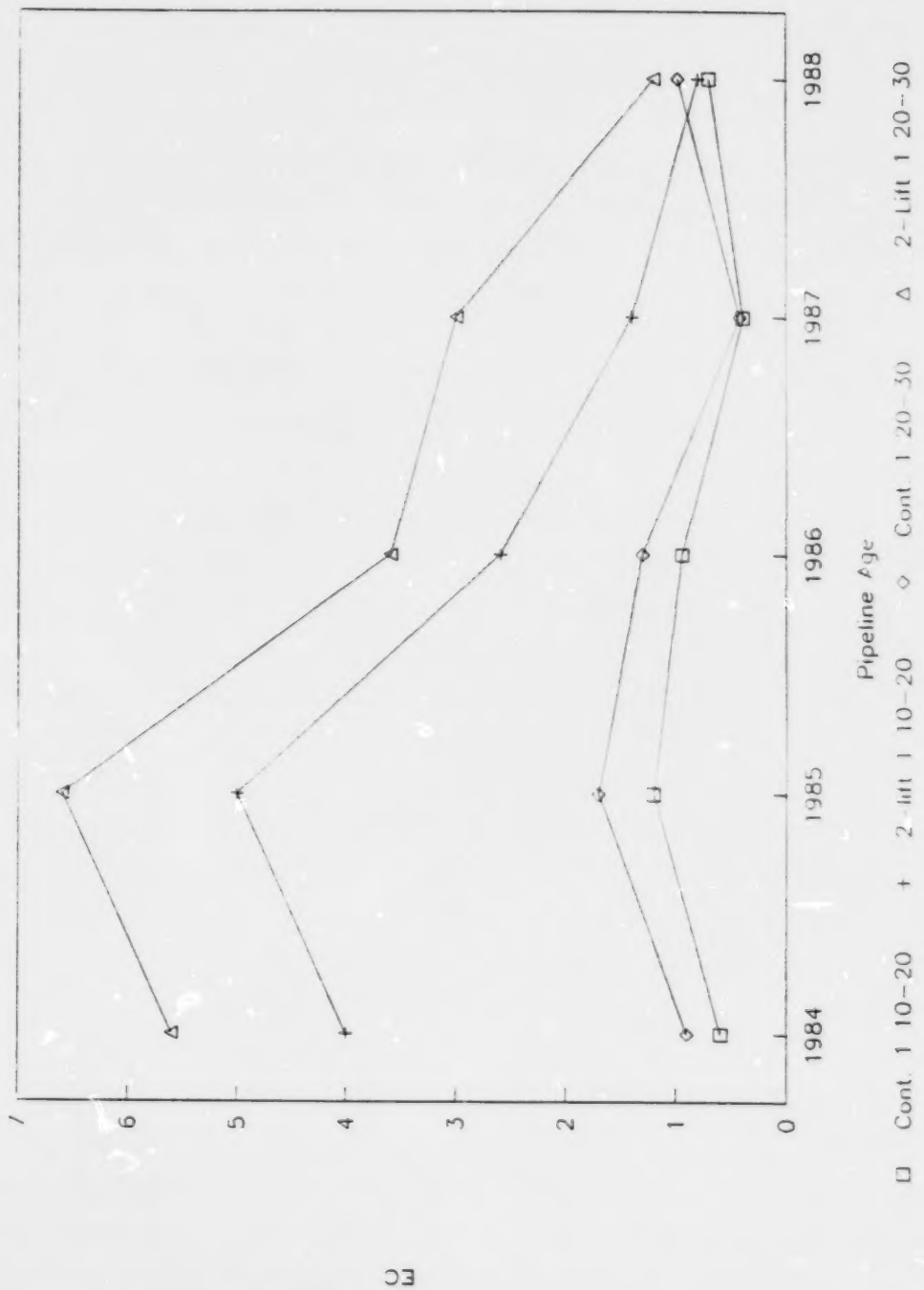


Figure 6. Standard Two-lift Results - E.C. Comparison

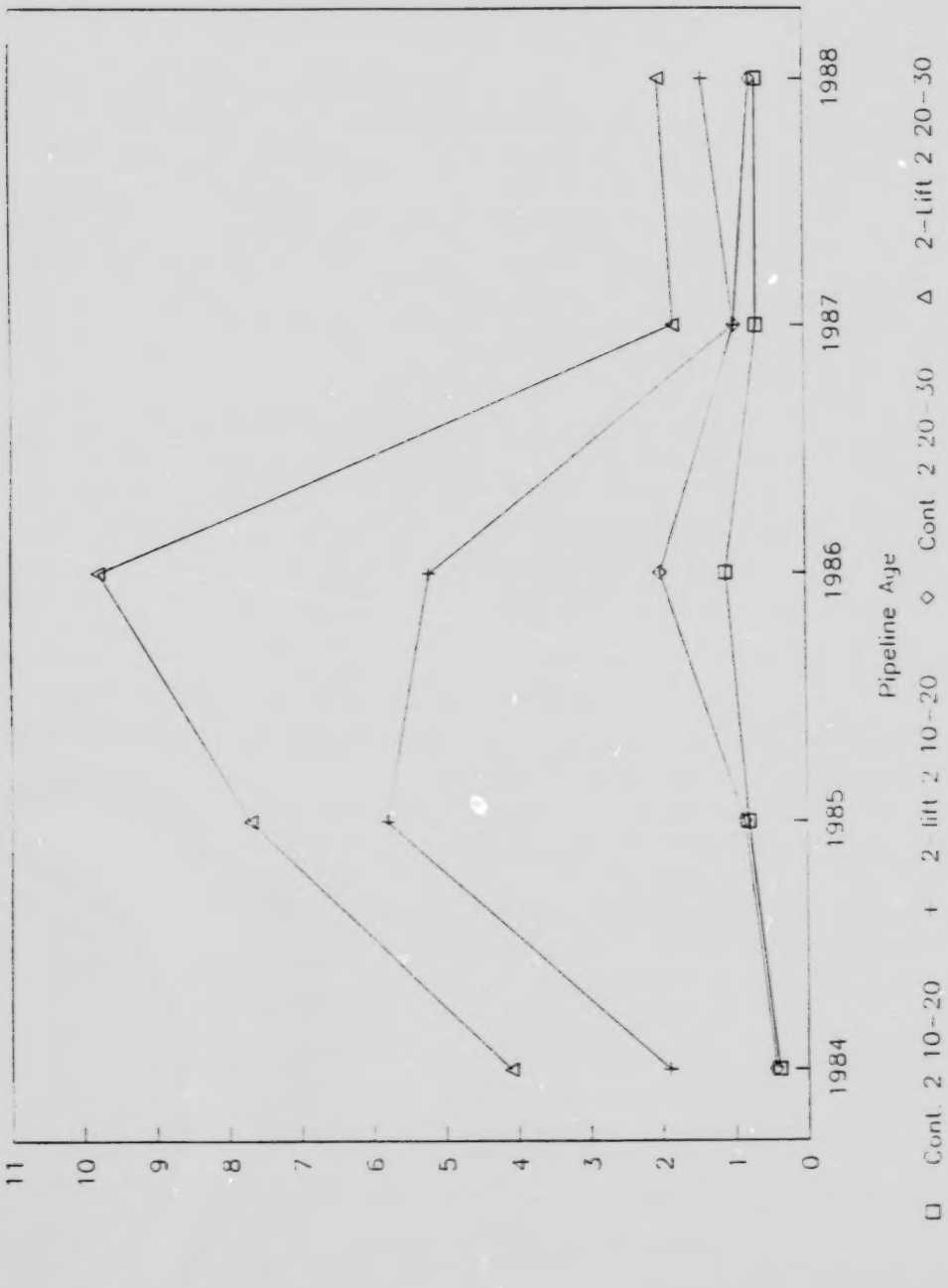


Figure 7. Standard Two-lift Results - SAR Comparison

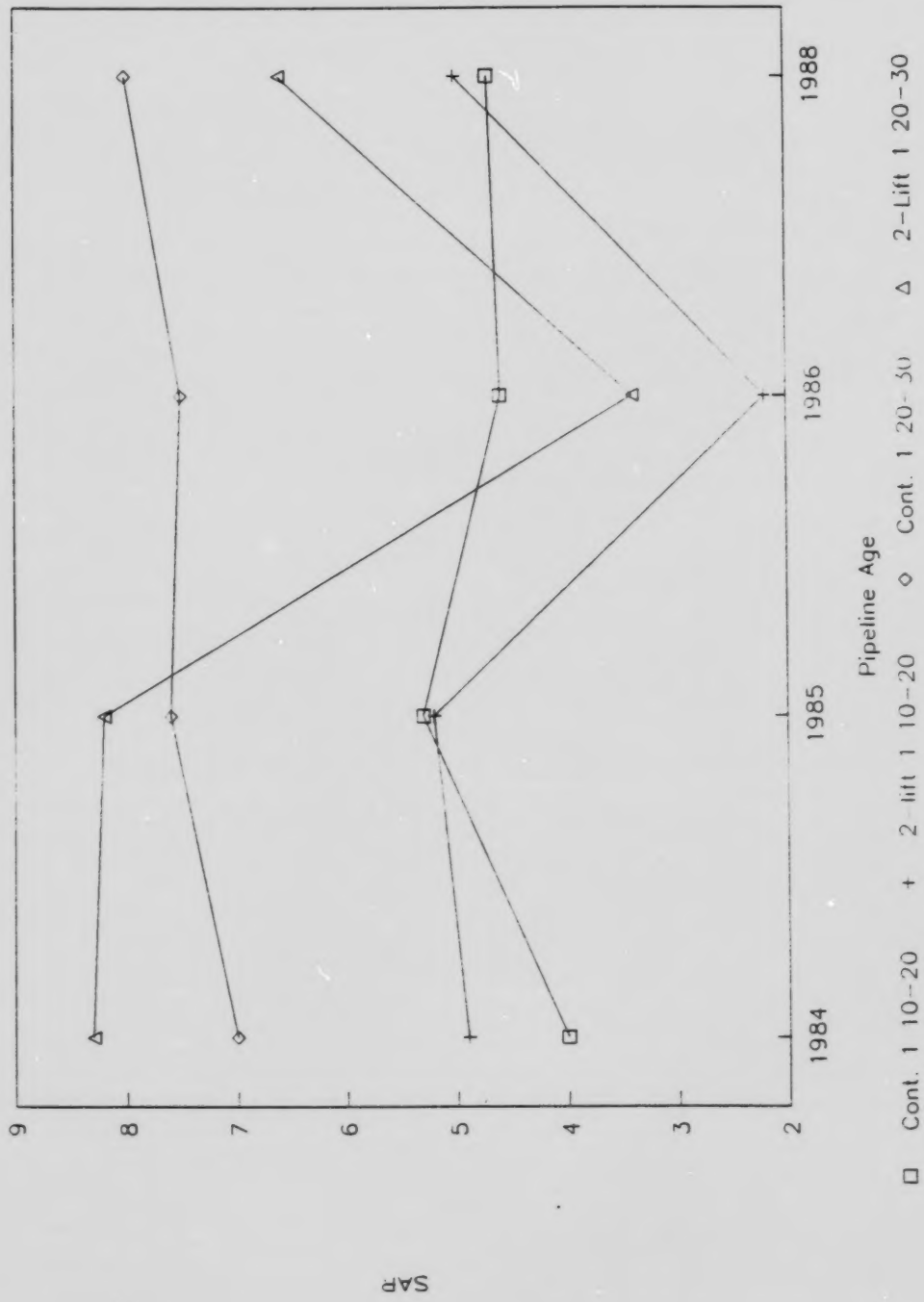
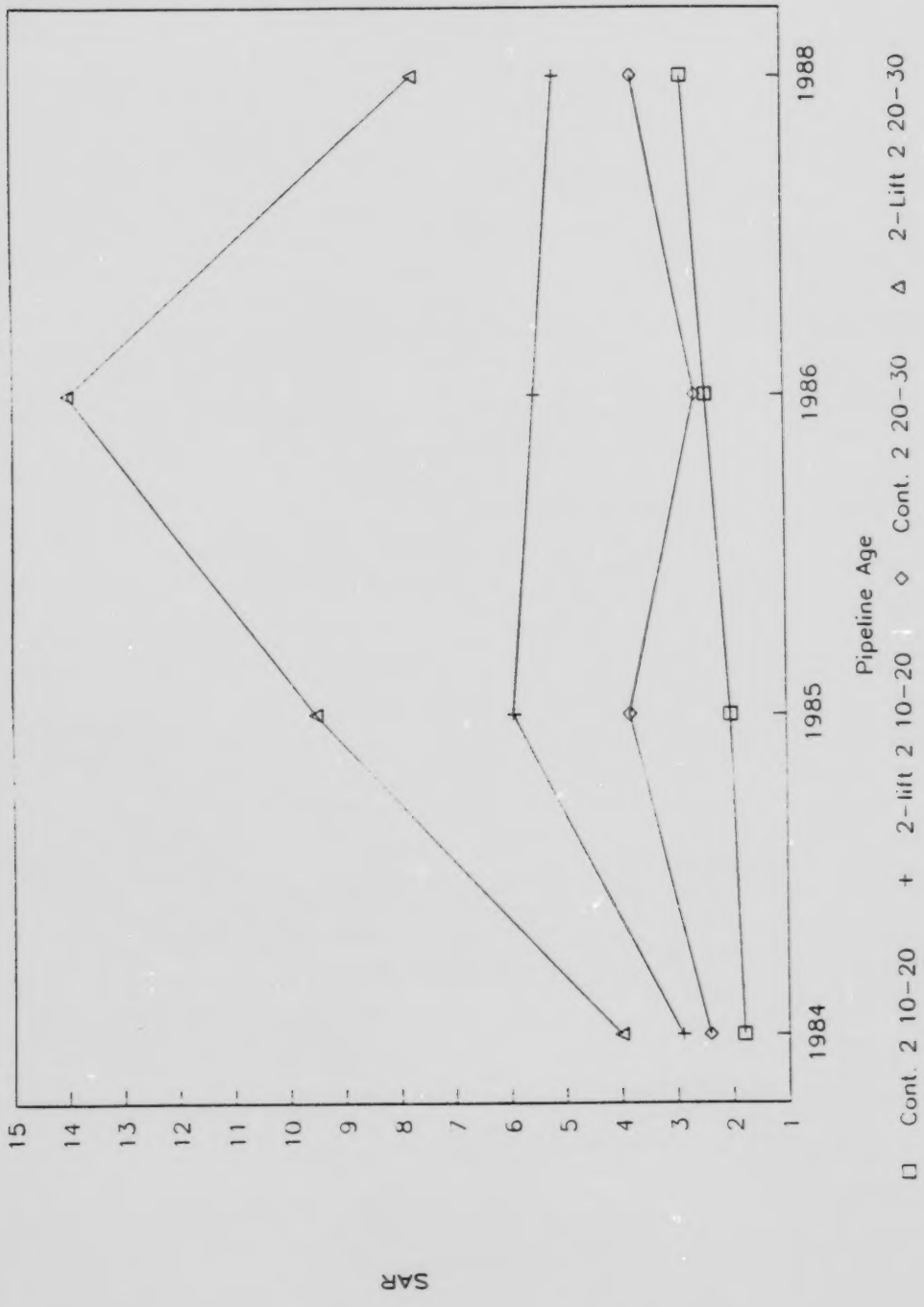


Figure 8. Standard Two-lift Results - SAR Comparison



1976 pipe trench was at least 1.6 m and the 1972 trench was at least 1.2 m in depth. These depths likely mean "poor quality" subsoils were encountered during construction.

Results of E.C. analysis of samples from the 0 to 20 cm depth shows similar levels in all pipelines (Figure 9). In the 20 to 40 cm depth interval, the 1976 and 1972 pipelines exhibit E.C. levels which are very acceptable. E.C. levels at the 40 to 60 cm depth are also acceptable in the 1976 and 1972 pipelines.

In summary, E.C. and SAR (Figure 10) in soils at pipelines installed in 1976 and 1972 are at acceptable levels for all three depths sampled. Levels in the adjacent pipeline installed in 1990 are higher than desirable, but are expected to decrease to acceptable levels based on experience elsewhere with two-lifted soils.

16.1.4 Mining Research Applicability

With the lack of research on pipelines and relatively more abundant research on open pit mines in western Canada and the U.S. there is a tendency for people to take results from mining and apply them directly to pipelining. Extreme caution must be used if one is going to make this major "leap of faith". This is not to say that none of the mining research is applicable, but that care must be taken when making interpretations and even then, only trends should be transferred.

In the accompanying chart, "Mining and Pipelining - Different", an attempt has been made to highlight some of the differences between mining and pipelining. A mine creates a major disturbance in a local area, it is an extensive excavation horizontally and vertically, materials handled are mostly bedrock material, materials are moved around the mine site, materials are often stored for a lengthy period of time and materials are replaced (and packed) using heavy equipment. These activities totally change soil physical parameters and disrupt water regimes which make predictions of the salinity/sodicity dynamics of the reconstructed soil very difficult.

In comparison, a pipeline is a minor excavation which generally involves disturbing only surficial materials and it is a linear disturbance with trenches normally about one metre in width. Soils are removed and replaced in comparatively short time-frames, they are not moved around the pipeline, materials are replaced into the trench using grader or dozer blades and replaced trench soils are not repeatedly driven over with heavy equipment as is

Figure 9. Battle River Three-lift Results - E.C. Comparison

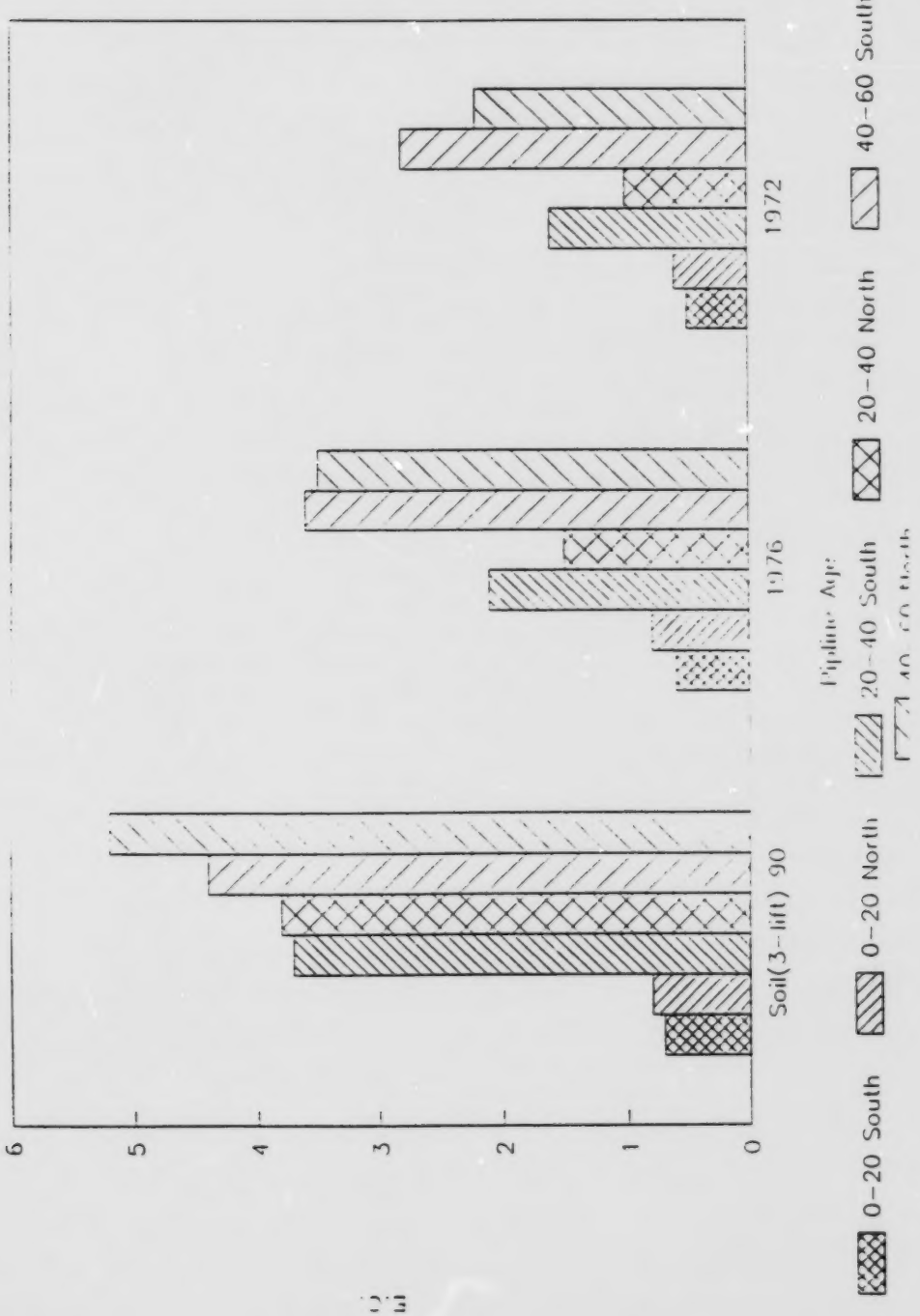
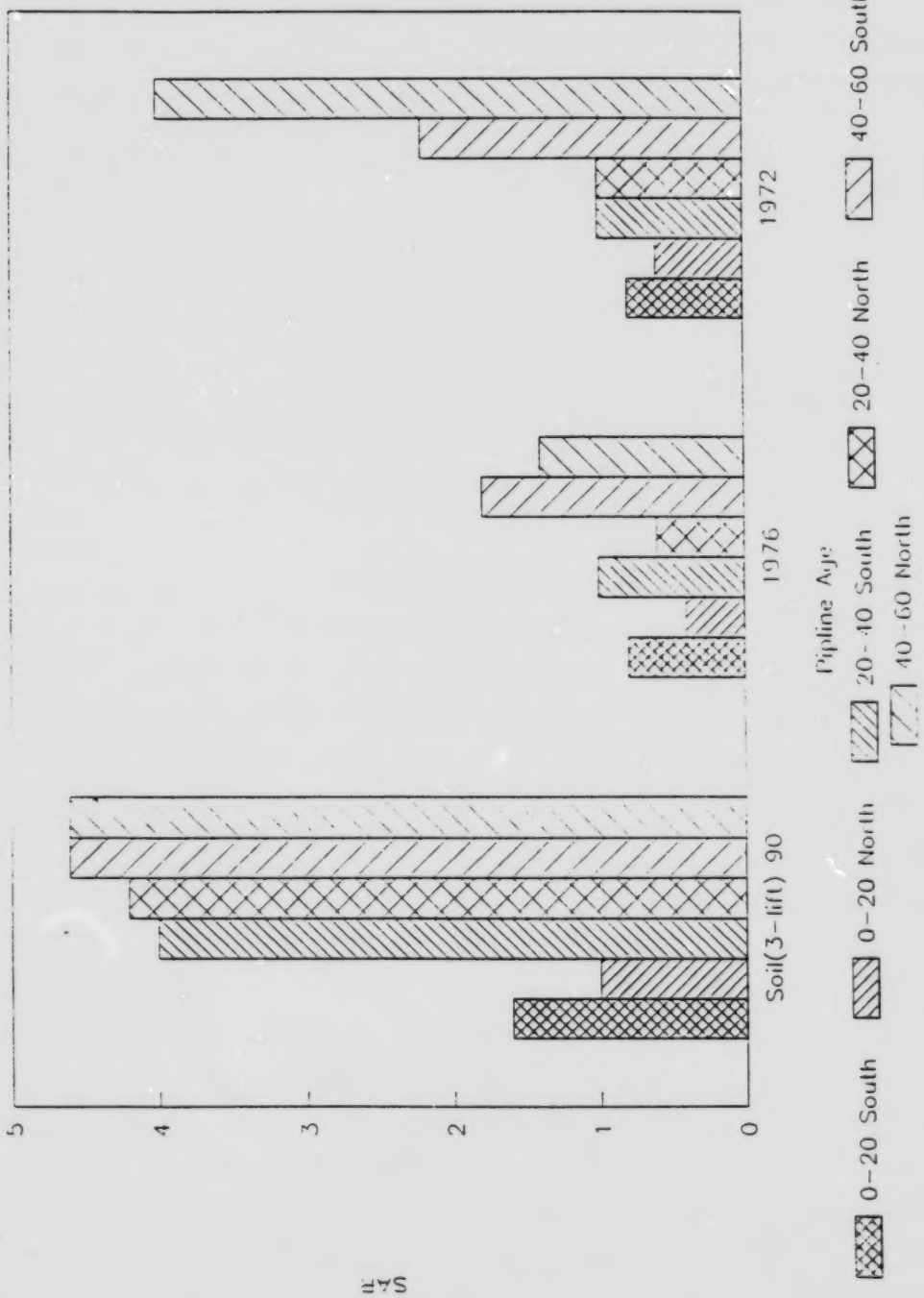


Figure 10. Battle River Three-lift Results - SAR Comparison



done in mining. Water relations in areas adjacent to the trench remain and re-establishing salinity/sodicity dynamics is much more predictable in the trench than in a mined area.

Mining and Pipelining - Different

Mining	Pipelining
• Mostly bedrock material	• Surficial materials
• Extensive excavation (depthwise)	• Minor excavation (1 m trench normally) (0.8 m of cover over pipe)
• A real disturbance (whole field re-construction)	• Linear disturbance (small part of field)
• Disrupts water table and aquifers (takes time to re-establish water table)	• Seldom encounter water table
• Water relations are unpredictable	• Water relations remain
• Salinity/sodicity dynamics are unpredictable	• Salinity/sodicity dynamics are predictable
• Options to move materials around	• No option to move materials
• Major environmental impact (making new landscape)	• Similar to farmer installing tile drains on farm (no change to landscape)

In closing this discussion, with mining there is a major environmental impact as new landscapes are often created in the form of new agricultural land, lakes or wildlife habitat. Pipelining is more similar to a farmer installing a tile drain on his farm in terms of the relative disturbance.

16.2 PREDICTION OF SOIL PERFORMANCE

16.2.1 Criteria

It is clear that there is a need to develop appropriate criteria for identifying (initially screening) soils with strongly contrasting, undesirable subsoil layers. The current Interim Criteria are inappropriate and should be withdrawn as they include criteria such as pH which, it is suggested, should not be a criteria. Also, all criteria are considered equal and some are clearly inter-related and at best, there should be some weighting of the criteria. In addition, the classes are too rigid and they do not bring soil spatial or temporal variability into

the equation. The soil parameters E.C. and SAR vary considerably in their concentrations at a sample point during the year.

To illustrate this variability, Table 8 was assembled. The numbers were obtained from control plots of about 10 by 70 m (each) in a NOVA study near Youngstown, Alberta. The 6/7 samples were obtained June 7 and the 10/1 samples on October 1, 1990 from the same plot, though not the same hole. It should be noted that some of the sample depths increased and some decreased one full soil suitability class when rated by the "Soil Quality Criteria Relative to Disturbance and Reclamation". These changes occurred on a sample area of 70 m, and if this magnitude of variability can occur on such a short length of area, saying that an E.C. of 2.9 for subsoil based on one soil survey sample deserves a soil quality rating of Good and an E.C. of 3.1 deserves a rating of Fair, based on a one-time sample, is not using good soils judgement and data interpretation experience/skills.

Table 8. E.C. and SAR Change Over Four Months.

Parameter[a]	Sample Depth	C1 6/7	C1 10/1	C2 6/7	C2 12/1	C3 6/7	C3 10/1	C4 6/7	C4 10/1
E.C.	0 to 10	0.37	0.57	0.43	0.39	0.41	0.30	1.84	0.45
	10 to 30	0.43	3.50	2.93	0.89	0.89	0.95	2.48	0.50
	30 to 60	4.50	7.96	7.90	7.53	2.17	1.59	5.39	3.90
	60 to 100	6.69	9.34	10.16	11.01	5.61	5.49	7.71	7.30
SAR	0 to 10	0.71	3.0	0.59	0.60	1.20	0.6	5.91	0.8
	10 to 30	2.34	11.8	1.12	3.70	5.19	3.9	9.12	3.8
	30 to 60	13.02	25.4	22.34	23.90	17.25	13.5	25.30	20.1
	60 to 100	17.21	23.0	26.08	29.60	36.17	34.0	26.02	27.3

[a] Means of eight cores from 10 x 70 m sample area.

Location: Youngstown

Based on the reasons just stated, it is recommended that the criteria for undesirable subsoil found in the draft "Manual on Soil Conservation Procedures for Pipeline Construction on Agricultural Lands" be implemented in place of the Interim Guidelines (Table 9). These criteria are based on strongly contrasting, undesirable properties, and use a sliding scale to change from one class to another rather than a rigid boundary. The primary

properties are E.C., SAR and Stone Content and take into account soil variability in space and time.

Table 9. 1985 Guidelines - Undesirable Subsoil Criteria.

Property	Desirable Material (2nd lift)	Undesirable Material (3rd lift)
Electrical Conductivity (E.C.)	≤ 5 5 to 10 > 10	at least 4 units higher at least 6 units higher N.A.
Sodium Adsorption Ratio[a] (SAR)	< 8 8 to 12 > 12	at least 6 units higher at least 8 units higher N.A.
Saturation Percentage[b]	--	at least 40% higher than desirable material
Stone Content (% Vol)	< 3 3 to 25 25 to 50	> 25 > 50 N.A.

[a] SAR criteria apply only to materials that are loam to heavy clay in texture. Criteria may be altered by the presence of high levels of either lime or gypsum in excess of other soluble salts.

[b] Saturation percentage criteria apply only to weathered bedrock materials.

N.A. Not Applicable - multiple lift of the subsoil is not required.

16.2.2 Models

There is a need to develop appropriate models for predicting post-construction soil quality using pre-disturbance information. A simple arithmetic calculation is not appropriate. This model should consider the soil profile, the landscape, climate and land use.

If the concept of "equivalent capability" is to apply, the presence of capability limiting factors such as climate and topography must be considered - not just soil chemistry parameters. For example, if a soil is rated as Capability Class 3 or 4 due to climate, the same subsoil chemistry criteria would not be used as one would for a Class 1 soil.

16.2.3 Standards

Another step which should be taken, is to develop appropriate post-construction soil quality standards. These would be the reclamation target which industry would then strive for when pipelining.

16.2.4 Planning Database

It is recommended that the criteria developed in Sections 16.2.1, 16.2.2 and 16.2.3 be applied to every soil series in Alberta. The objective would be to develop a "Soil Reclamation Planning Database" which would include recommended soil handling procedures and other practices for each soil series. The example (Table 10) was prepared by Pedocan Land Evaluation Ltd. of Edmonton. The idea is that this database would be developed, based on our current understanding, and it would represent a "normal" situation. The database would also flag potentially troublesome soils. At this point, more sample points could be established and different techniques identified for handling, etc. if a pipeline encountered one of these soils. The database would be periodically reviewed and updated.

16.2.5 Monitoring

Soils, crops and related problems of pipelines should be monitored in a systematic fashion to more clearly define what problems exist and/or are being created. What is being discussed are "as-built" reports. Data collected would be interpreted and used to update recommended practices.

16.2.6 Soil Handling Plans

Soil handling plans within pipeline Development and Reclamation (D&R) applications would be developed using recommended practices for each soil series. If there are exceptions proposed, an alternative practice would be presented and rationalized. The recommended practices would be reviewed periodically (perhaps annually, initially) outside of the D&R approval process.

Table 10. Soil Information for Pipeline Planning

File No: 90002
CESSFORD-N. LATERAL

Soil Series: BINGVILLE
Series Code: BVL
Soil Zone: BROWN
Soil Classification: ORTHIC BROWN CHERNOZEM
Parent Material: GLACIOFLUVIAL
Landform/Slope: GFb/ /1-5%

Agroecological Resource Area: E3
CLI for Agriculture: 5S

Typical Soil Profile No: 45

Horizon # Name	Depth	Color	Texture V R	Structure	Consistence V R	pH V R	SAT% V R	EC V R	SAR V R	Combined Rating
1 AH	0-14	4/3	SL G	SG	Loose F	6.5 G	42 G	0.3 G	0.3 G	F
2 BM	14-55	5/4	SL G	SG	VFRI-L G-F	6.7 G	38 G	0.2 G	0.3 G	F
3 CK	55-100	6/4	VFSL G	SG	VFRI-L G-F	7.9 F	39 G	0.4 G	0.6 G	F

PIPELINE RATINGS

Topsoil Stripping Depth: 15 cm
Wind Erosion Risk (S/M/H): H
Water Erosion Risk - S: 9 % slopes
- M: 9-15% slopes
- H: 15 % slopes

Compaction Risk (Y/N): N
Rock Picking Requirement (Y/N): N
High Seasonal Watertable (Y/N): N

Potential Three-phase (Y/N): N
Trenchwall Instability (Y/N): Y
Hayland Revegetation
Seedmix: -
Fertilizer: 18N-26P-10S

Pasture Revegetation
Seedmix: -
Fertilizer: -

Special Procedures and Notes: COARSE LOAMY TEXTURES MAY HAVE UNSTABLE TRENCH WALLS WHEN VERTICALLY DITCHED

Pedocan Land Evaluation Ltd.

16.3 DATA GAPS

When assessing data gaps, it is important to separate soils handling implementation problems from problems due to soil materials. The difference is that if we know what to do and the implementation is poor, this does not mean the soils handling technique was wrong. If the problem can be remedied simply by providing an environmental inspector on the task, this is not a data gap, but, it is important to know when deciding if the soil handling technique was wrong and also in deciding what research needs to be done and what priority to assign to it.

16.3.1 Quantification of Problem(s)

There is a data gap with respect to the magnitude and extent of problems caused by pipelining. Problems must be quantified and related to the soil type and other factors. There should also be some effort extended to identify why there are no problems on the same soil type in similar situations elsewhere. That is, not only the problem areas should be examined, but so should "good" areas on the same soil type to provide data as to how to "do it right".

16.3.2 Monitoring

Another step which should be taken to assist in improving the database is the collection of monitoring data for soils and crops on pipelines. This can be accomplished through the use of "as-built" reports submitted for selected pipelines by the parent companies. If designed properly, these could provide data currently missing and would assist in the updating of the information on each soil series.

16.3.3 Research

There are some serious gaps in understanding the effects of mixing soil horizons and the interactions of soil properties. These data are needed in order to develop and refine the prediction models discussed earlier.

Some topics whioh should be considered for research are:

1. Effects of subsoil mixing, what ratios.
2. Effects of overstripping (taking more than "topsoil").

3. Soil water and salt dynamics in trenches.
4. Effects of sodium in soils with high lime and gypsum content.
5. Crop sensitivity to soil property change.
6. Importance of B horizons, minimum and maximum thickness.
7. Relationship of soil impacts to landscape position.
8. Problems related to sandy subsoils.
9. Problems related to clayey subsoils.
10. Effect of time in alleviating subsoil problems.
11. Problems related to bedrock subsoils.
12. Problems related to Solonetzic soils.

16.4 CONCLUDING REMARKS

This presentation has attempted to point out some of the things that are unknown, as well as pointing out what is wrong with using the existing Interim Three-lift Criteria and provides suggestions as to what to replace those criteria with. Data were also presented which support the suggestion that with a little time, three to five years in the case of the Standard Lateral, E.C. and SAR levels do decrease to off-right-of-way field levels in pipeline trenches even when construction is conducted using a conventional two-lift procedure.

In closing, it is hoped that this presentation has provided some "food for thought" as we progress through this workshop.

16.5 LITERATURE CITED

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deJong, E. and R.G. Button, 1973. Effects of pipeline installation on soil properties and productivity. Canadian Journal of Soil Science 53:37-47.

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Naeth, M.A., 1985. Ecosystem reconstruction and stabilization following pipeline construction through Solonetzic native rangeland in southern Alberta. M.Sc. Thesis, University of Alberta. Edmonton. 196 pp.

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17. FIELD DATA TO SUPPORT POSITIONS - QUESTIONS

Industry — The data were for down to 30 cm, are there data for deeper levels?

Industry — There are deeper data, but we concentrated on the depth to 30 cm since this is the area in question here.

Industry — Where did the salt go? The maximum depth was to 50 cm.

Industry — There is a problem coring above the pipe, therefore, only 50 cm is sampled. I'd suggest the salts are below this.

Industry — Were examples only well-drained sites, or were there some poorly drained sites?

Industry — We did not have free choice in choosing the sites. Alberta Environment recommended some of the sites.

Consultant — The sites were selected to be as uniform as possible. They included a variety of landscapes. All were lacustrine sediment over till. We tried to use sites with similar topography.

Government — Regarding E.C., the change was not always decreasing; some results showed increases. Sampling times may be important. In planning and evaluation of D&R plans do we need several points of time in sampling to get adequate information?

Industry — No, I don't think so. We must take into account that there is variability and adapt the criteria to allow for this variability. Therefore, we propose a different system, with a sliding rather than a definite scale.

Government — In the example, samples were taken two months apart? (Answer: four months) How far apart were the samples taken? (Answer: within the 10 X 70 m area) I would suggest that the results show sampling variability, not actual change over time.

Industry — Yes there is some variability, but there is some change over time.

Government — There is a need to estimate sampling variability within an area initially, before you can compare to a later date.

Industry — We're not saying everything is the same. This just shows some of the variation that can be observed.

Consultant	The Battle River Soil Reconstruction Plots showed that there are high densities on replaced materials, these are not observed on pipelines. This illustrates that the problem is physical, more than chemical. Pipeline trenches are not so dense, leading to a more open structure, better leaching, etc. especially in the upper 30 to 40 cm.
Government	I would agree. We saw that physical properties had not changed much over time (10 to 15 years), although E.C. and SAR had. The density and structure has not changed.
Consultant	The freeze/thaw process doesn't loosen up the subsoil. Natural amelioration is a slow process. We have to get the material back in as good a shape as possible. This is more important than some of the other things we're looking at.
Government	The data presented for improvement of soils (Battle River) were for Solonetzic and Chernozemic soils. We don't use three-lift on these. Is there any information to suggest the same trend on a three-lift soil.
Industry	The comparison is done on Standard Line and Battle River results. We saw a decrease in yield on the right-of-way using two-lift or three-lift, but later, there are no differences we can see.
Government	Are you saying that for Battle River we have seen leaching of salts to return to normal E.C. levels?
Industry	Yes.
Government	The 1972 pipeline may have a 1.2 m rather than a 2 m cover for three-lift. Therefore, for three-lift soils in a windrow you would expect higher numbers. It's not apples and apples.
Industry	I don't think we can say that. We don't have records to show the details of the pipelines.
Government	You can't compare pipelines at 1 m difference in depth.
Industry	Between the '72 and the '90 pipeline there shouldn't have been much difference.
Industry	The '72 pipeline, if it was a 24" line, would be very similar in trench depth to a three-lift situation.

Industry	0.8 m is the minimum amount of cover over a pipe.
Consultant	The saline Elnora soil was identified as needing three-lift. We sampled the '72 and '76 pipelines to try to see if this was true.
Government	Without the original data from the '72 pipeline we're getting a misleading situation.
Industry	The data have limitations, but they are better than mining data.
Government	You want to use 14 to 18 year old data to prove that two-lift shows decreased E.C., but you don't want to wait that long to have the three-lift prove itself. The data may show up as it does because the three-lift was done, and maybe not correctly.
Industry	At the time, Alberta Environment approved the three-lift approach for this line (Standard Line). We and Alberta Environment both recognize problems with this now. I didn't say we need to research implementation techniques. We have to separate problems with design from problems with implementation. We don't need research for research sake, but to address the real problems. Don't research problems that could be corrected with proper implementation.
Government	In dealing with salt and salt movement, water is important. Did anyone look at water movement on these sites?
Industry	No. It is a weakness. We need monitoring right on the site.
Government	Has there been any work on movement of water in the profile?
Industry	No work has been done.

18. SOIL HANDLING METHODS FOR TWO-LIFT AND THREE-LIFT - REGULATORY AGENCY PERSPECTIVE - BOB ONCIUL[11]

As stressed up to this point today, the main objective of the regulatory government bodies during pipeline construction is to ensure that disturbed soil profiles be maintained so as to return chemical and physical soil properties to a condition consistent with the pre-disturbance state.

If the above is accomplished, then and only then is equivalent soil capability achievable.

With equivalent soil capability return as a government policy, we consider the following examples of soil handling procedures or modifications of these procedures as alternatives to achieve our goals and objectives. Each soil handling procedure is illustrated and clearly described to identify the soil handling operation, limitations to the procedure and potential modifications.

18.1 NORMAL TWO-PHASE (See Figure 11)

1. Topsoil stripping width - trench and spoil.
2. BC mixture placed on unstripped B.
3. Excessive BC mixture is feathered out over clean B reducing suitable rootzone depth.
4. Result is reduced rootzone and keeping topsoil evenly spread.

18.2 OPTION A - THREE-PHASE (See Figure 12)

1. Topsoil stripped from work side and spoil side.
2. B is stripped from trench, feathering area equal on both sides of centre line and storage area.
3. If pulverization of B on work side and wind erosion is a concern, use of soil stabilizers on stockpiles and on B material on work side may be required.
4. On graded areas, all topsoil could be stored on high side of right-of-way.

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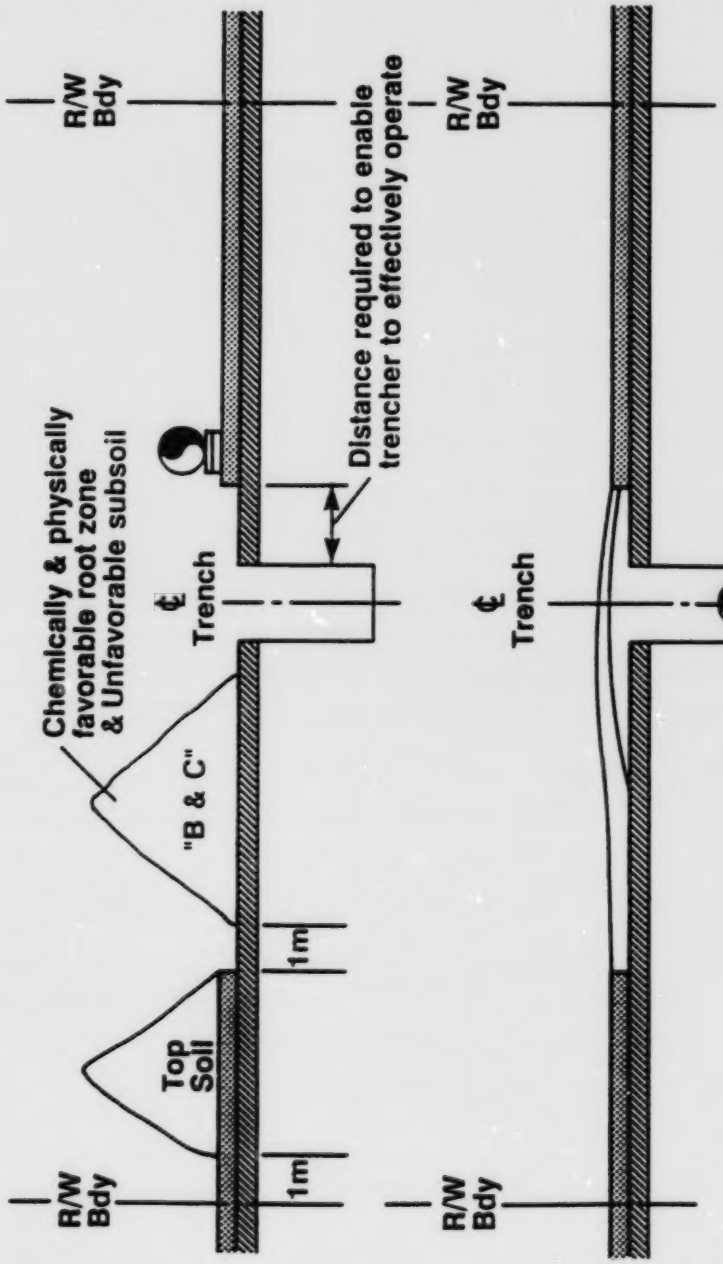
[11] Senior Reclamation Officer, Alberta Environment.

Figure 11. Normal Two-phase Soil Handling Cultivated Land

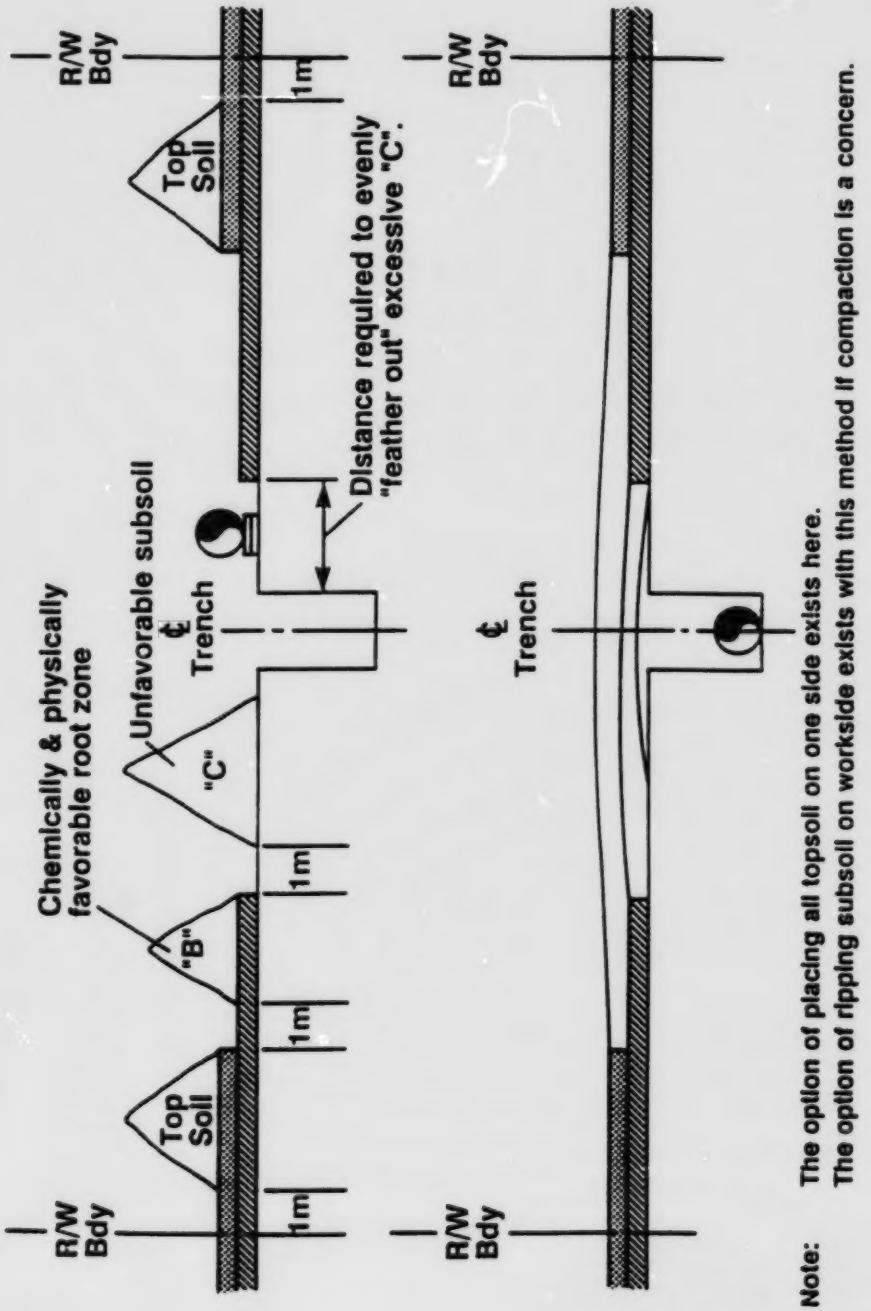


Note: Due to bulking factor of subsoils & pipe displacement, unsuitable "C" is layered over "B" reducing root zone.

Due to above, topsoil replacement over reach is difficult to achieve evenly.

Preferable method of topsoil salvage on workside is available.

Figure 12. Option "A: - Three-phase Soil Handling Cultivated Land



Note: The option of placing all topsoil on one side exists here.
The option of ripping subsoil on workside exists with this method if compaction is a concern.

5. If grading is excessive to the extent that it will extend into the C, then graded material must be separated into B and C storage.
6. Pipe lay up area may be located on B if more desirable.

18.3 OPTION B - THREE-PHASE (see Figure 13)

1. Topsoil stripping width includes trench, feathering area and spoil side.
2. Topsoil can either all be stored and flattened on work side or split as shown.
3. B stripping includes trench, feathering area and C storage.
4. On rights-of-way requiring grading, conventional stripping as in Option A would be required.
5. Pipe lay up area may be located on topsoil if more desirable.
6. This procedure is not recommended in arid and windy areas of the province.

18.4 THREE-PHASE SOIL HANDLING FOR GRASSLANDS (see Figure 14)

1. Topsoil stripping includes trench, feathering area and B and C storage.
2. B soil salvage includes trench, feathering area and C storage.
3. Pipe lay up area may be located on topsoil if desirable.
4. Use of soil stabilizers may again be required if wind erosion of stored material and pulverization of sod is a concern.
5. On graded areas soil handling as in Option A for cultivated land would be required.

18.5 CONCLUSION

It is the Regulatory Agency's position that considering physical and chemical soil limitations and various ecoregions in the province, to reclaim disturbed soil profiles and maintain equivalent soil capability:

1. There are soil handling procedures which have been successfully implemented to achieve the required objective of equivalent soil capability.

Figure 13. Option "B" - Three-phase Soil Handling Cultivated Land

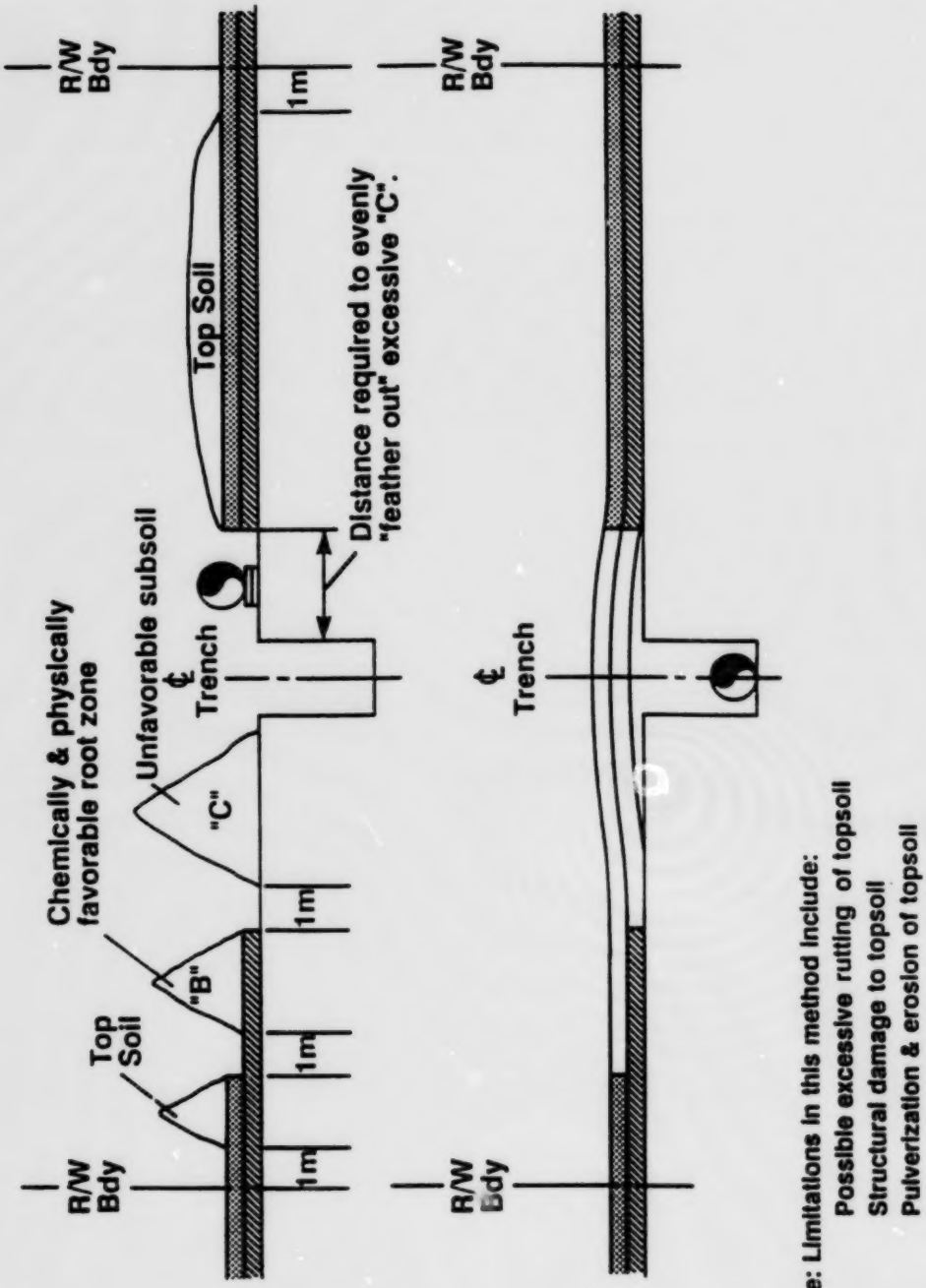
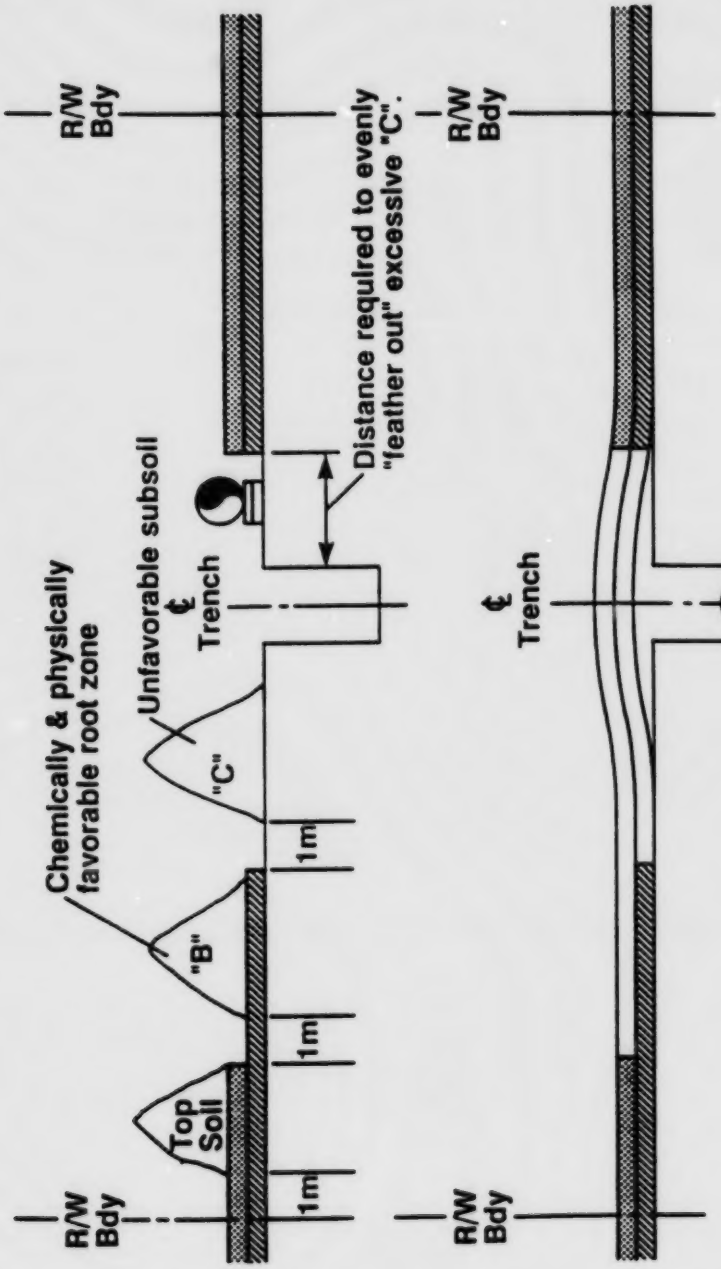


Figure 14. Three-phase Soil Handling for Grasslands



Note: If pulverization of sod & topsoil is a concern, or if compaction of topsoil & subsoil is a concern, stripping of topsoil on workside is required.
If it can be demonstrated that scalping of sod under "B" storage or excessive deposition of "B" on sod is not a concern, stripping of topsoil in this area may be waived.

2. It is required to retain three-lift as a soil handling procedure alternative.
3. Qualified and continuous field inspection is required to implement required and approved soil handling procedures. This inspectional obligation is also required to "further define" areas designated for three-lift.
4. Suitable contractor equipment to meet the approved soil handling procedures is essential (i.e., trench width).

In conclusion, from the experience obtained in the past year or better, it is my consensus that good progress has been made to maintain soil capability in situations where adverse physical and chemical soil properties in subsoil materials exist. There are modifications to present procedures that are available to achieve even better results, and with continued cooperation between government and industry, everyone's goal of soil conservation can become a reality.

19. SOIL HANDLING METHODS FOR TWO-LIFT AND THREE-LIFT - THREE-LIFT WORKSHOP PRESENTATION - MIKE HOUSER[12]

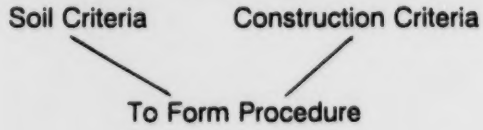
19.1 INTRODUCTION

Two-lift concept development:

1. Mid 70's acceptance.
2. Demonstrated benefits.
3. Still being refined.
4. Special situation and conditions.

Three-lift concept:

1. Varying opinions in industry and government.
2. No problem do nothing, to
   possible problem do something, to
   certain problem do this.
3. We have a soils problem, perceived or actual - open to debate - three-lift is one procedure proposed to alleviate the problem.
4. Question? is three-lift the only procedure that will achieve the desired results?
5. Development of any soil handling procedure is based on two sets of criteria



6. Remainder of presentation will focus on:
   a. construction procedures
   b. criteria developments.

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[12] Environmental Construction Specialist, NOVA Corporation of Alberta.

19.2 PROCEDURES

1. Purpose:
   a. not to fully understand all procedures.
2. Presented not as what is correct, but rather what is possible.
3. List is incomplete, just a range.
4. For each procedure, I will state where and when applied and the impact zones most affected. Idea is to demonstrate the impact of the pipeline as a whole to ensure that pursuing the benefit of a singular action or objective does not cause any increase in the overall impact.
5. Impact zones:

Both - horizontal plane
vertical plane

1. Trench.
2. Spoil areas and storage areas.
3. Total width stripped.
4. Work-pipe lay up area.
5. Travel areas.

19.3 SLIDE PRESENTATION

1. No strip:
   a. narrow ditch
   b. plough-in.
2. Ditch line.
3. Blade width.
4. Ditch and spoil.
5. Full width.
6. Extra depth stripping.
7. Trench three-lift; nine variations.
8. Double grade three-lift; ABC.
9. Double grade three-lift BC->A; four variations.
10. Winter extra depth two/three-lift.
11. Winter three-lift for rocky subsoils.

12. Emphasize procedures are developed based on the total impact we believe we are going to cause.
13. Parameters vary but full evaluation directs us to what is possible and worthwhile.

19.4 CONSTRUCTION PARAMETERS

1. Posed as questions, not set answers.
2. Costs:
   25% higher for trench three-lift
   up to
   100% higher for extra depth for two/three-lift.
3. Expressed as a % of right-of-way costs:
   $5,000 -> $50,000 per km.
4. Very significant.
5. Wide variation is in itself a problem.

19.5 CONSTRUCTION PARAMETERS FOR THREE-LIFT, FOR DISCUSSION ONLY

From these we develop criteria. Applied for removal - placement-replacement.

Time

1. Is practical execution in the construction sequence possible?

Equipment Capability

1. What are the accuracy tolerances?
2. Required operator skill levels?

Disturbance Width

1. Are there conflicts with:
   a. difficult revegetation?
   b. erosion potential?
   c. moisture loss?
   d. soil mixing or loss due to stripping?

Cost

1. How do the benefits compare with the costs?
2. Not as justification for not doing what is right, but for exploring what other alternatives might be available to achieve the same end.

A Horizon

1. At what topsoil depth below the plough zone do we achieve buffer effect?
2. Same benefits as overstrip?
3. Separation requirements from other materials.

B Horizon

1. Removal depth minimum:
   a. equipment tolerance,
   b. depth needed for effective buffer.
2. Removal depth maximum:
   a. space requirements,
   b. depth needed for buffer,
   c. equipment capability.
3. Removal depth in relation to minimum sample depth.
4. Texture:
   a. powdery Bm requires hoe removal,
   b. are translocation characteristics changed?
5. Moisture loss in disturbed B.
6. B horizon depth as % of ditch depth.
7. Placement separation from A and C.
8. Replacement characteristics.

Ratio of B/C Mix in Trench Spoil

1. What mix concentration will cause a significant capability shift for any given soil series?
2. Ditch depth if independent of pipe diameter - including special areas such as: road crossings; foreign line crossings; side bends; railroads.

Pipe Diameter - What Size Makes The Following Significant?

1. Depth of trench - B/C ratio - volume generated (space).
2. Width of trench - volume of spoil generated (space).
3. Volume displaced - depth of B/C mix on spoil area.
4. Width of spoil area affected.
5. Total disturbance width.

Effect of Conditions

1. Winter realities.
2. Wet removal:
   a. replacement (moist?),
   b. minimum depths concept.
3. Dry:
   a. revegetation and erosion problems,
   b. removal and replacement problems.
4. Ditch instability.
5. Others.

19.6 ALTERNATIVES

1. Narrow trench.
2. Plough-in.
3. Chemical treatment.
4. Physical treatment.
5. Overstripping.
6. Boring-drilling.
7. Patience - expanded management time frame.
8. New procedures and equipment when the situation is clarified.

19.7 CONCLUSION

1. Few conclusions.
2. Many questions.

3. At this time industry does know that three-lift increases in time, effort, and cost, justify serious benefit analysis.
4. Three-lift concept as it stands is not ready for routine application.

Figure 15. Topsoil Conservation Ditchline (Summer Construction)

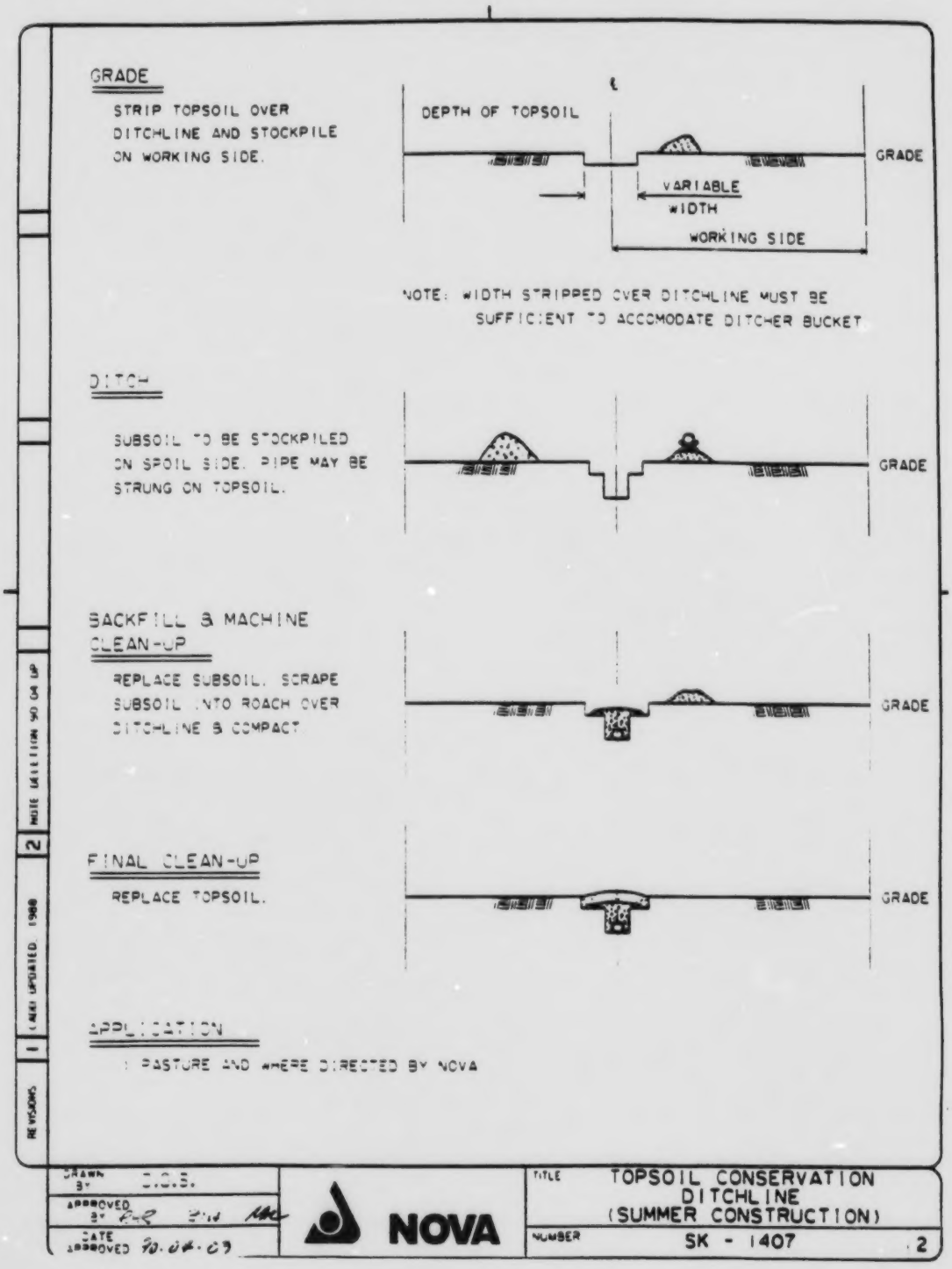


Figure 16. Topsoil Conservation Blade Width (Summer Construction)

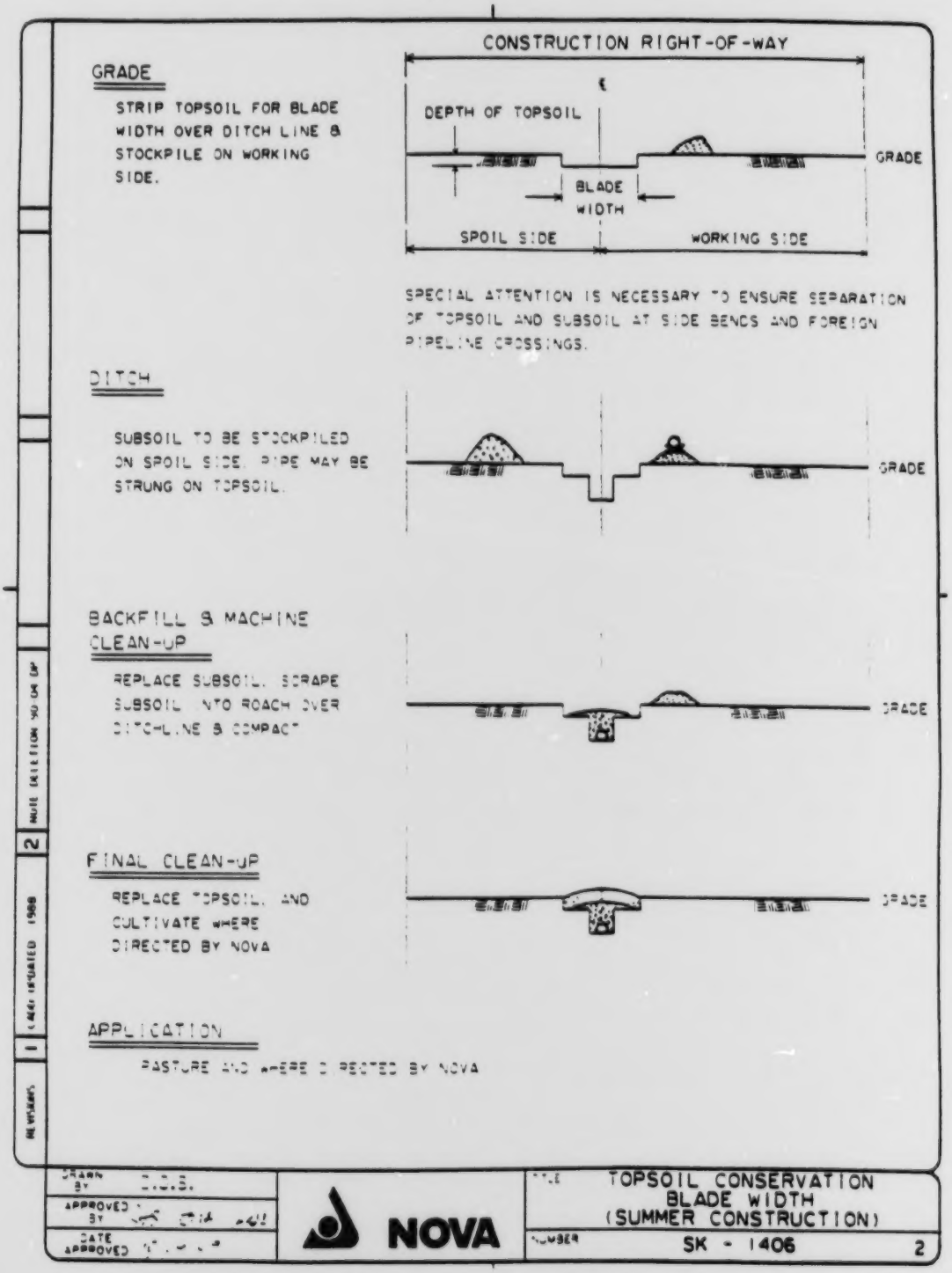

CONSTRUCTION RIGHT-OF-WAY
GRADE
STRIP TOPSOIL FOR BLADE WIDTH OVER DITCH LINE & STOCKPILE ON WORKING SIDE.
DEPTH OF TOPSOIL
BLADE WIDTH
SPOIL SIDE
WORKING SIDE
GRADE
SPECIAL ATTENTION IS NECESSARY TO ENSURE SEPARATION OF TOPSOIL AND SUBSOIL AT SIDE BENDS AND FOREIGN PIPELINE CROSSINGS.
DITCH
SUBSOIL TO BE STOCKPILED ON SPOIL SIDE. PIPE MAY BE STRUNG ON TOPSOIL.
GRADE
BACKFILL & MACHINE CLEAN-UP
REPLACE SUBSOIL. SCRAPE SUBSOIL INTO ROACH OVER DITCH-LINE & COMPACT
GRADE
FINAL CLEAN-UP
REPLACE TOPSOIL AND CULTIVATE WHERE DIRECTED BY NOVA
GRADE
APPLICATION
PASTURE AND WHERE DIRECTED BY NOVA
NOVA
TOPSOIL CONSERVATION BLADE WIDTH (SUMMER CONSTRUCTION)
SK - 1406
2

Figure 17. Topsoil Conservation Ditchline and Spoil Side (Summer Construction)

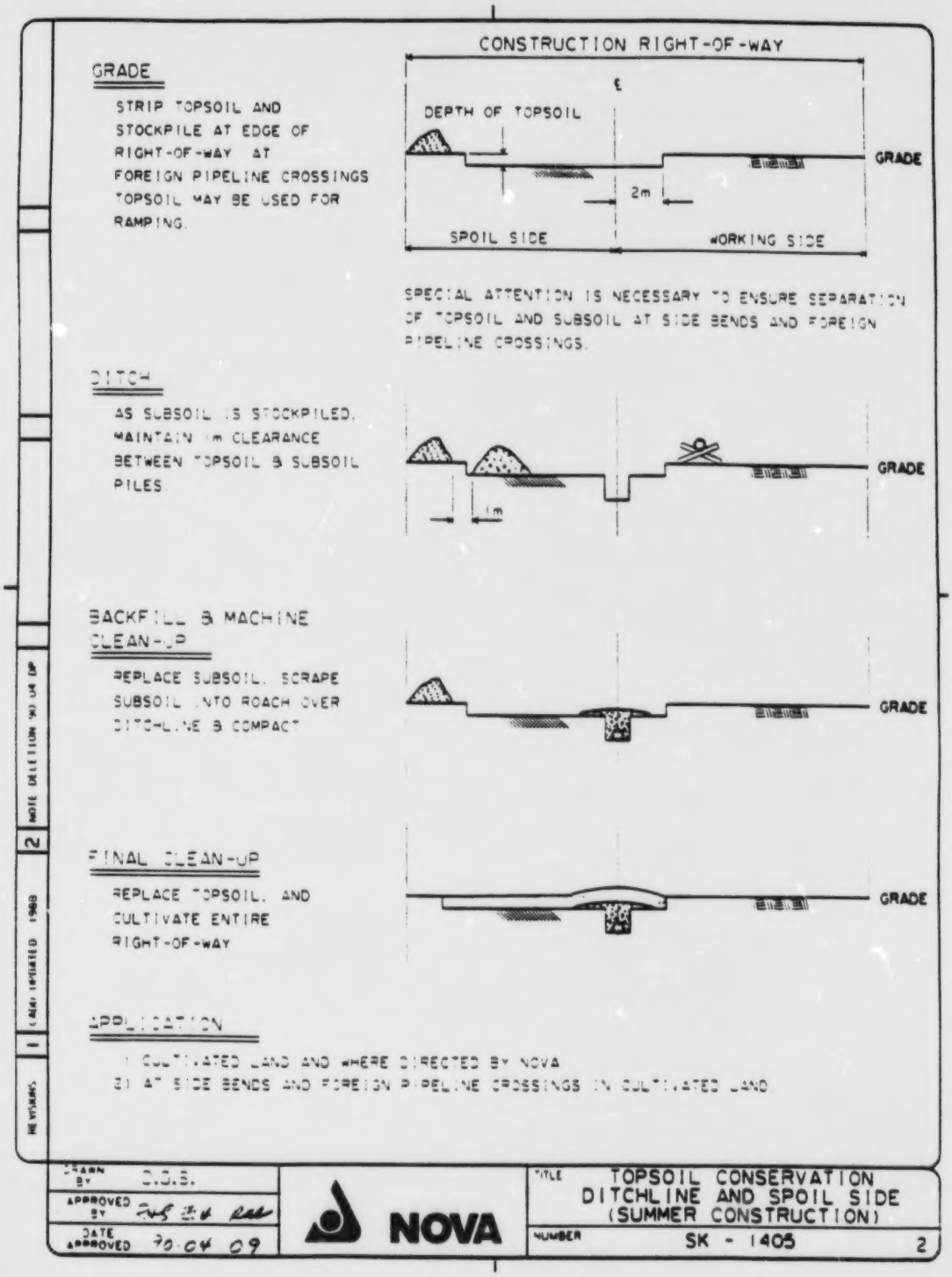

CONSTRUCTION RIGHT-OF-WAY
GRADE
STRIP TOPSOIL AND STOCKPILE AT EDGE OF RIGHT-OF-WAY AT FOREIGN PIPELINE CROSSINGS TOPSOIL MAY BE USED FOR RAMPING.
DEPTH OF TOPSOIL
GRADE
2m
SPOIL SIDE
WORKING SIDE
SPECIAL ATTENTION IS NECESSARY TO ENSURE SEPARATION OF TOPSOIL AND SUBSOIL AT SIDE BENDS AND FOREIGN PIPELINE CROSSINGS.
DITCH
AS SUBSOIL IS STOCKPILED, MAINTAIN 1m CLEARANCE BETWEEN TOPSOIL & SUBSOIL PILES.
GRADE
1m
BACKFILL & MACHINE CLEAN-UP
REPLACE SUBSOIL. SCRAPE SUBSOIL INTO ROACH OVER DITCHLINE & COMPACT
GRADE
FINAL CLEAN-UP
REPLACE TOPSOIL, AND CULTIVATE ENTIRE RIGHT-OF-WAY
GRADE
APPLICATION
1) CULTIVATED LAND AND WHERE DIRECTED BY NOVA
2) AT SIDE BENDS AND FOREIGN PIPELINE CROSSINGS IN CULTIVATED LAND
REVISIONS
1 (AG) INITIATED 1980
2 NOTE DELETION (c) OF DP
DRAWN BY D.D.S.
APPROVED BY
DATE APPROVED 79.04.09
NOVA
TITLE TOPSOIL CONSERVATION DITCHLINE AND SPOIL SIDE (SUMMER CONSTRUCTION)
NUMBER SK - 1405 2

Figure 18. Full-width Stripping

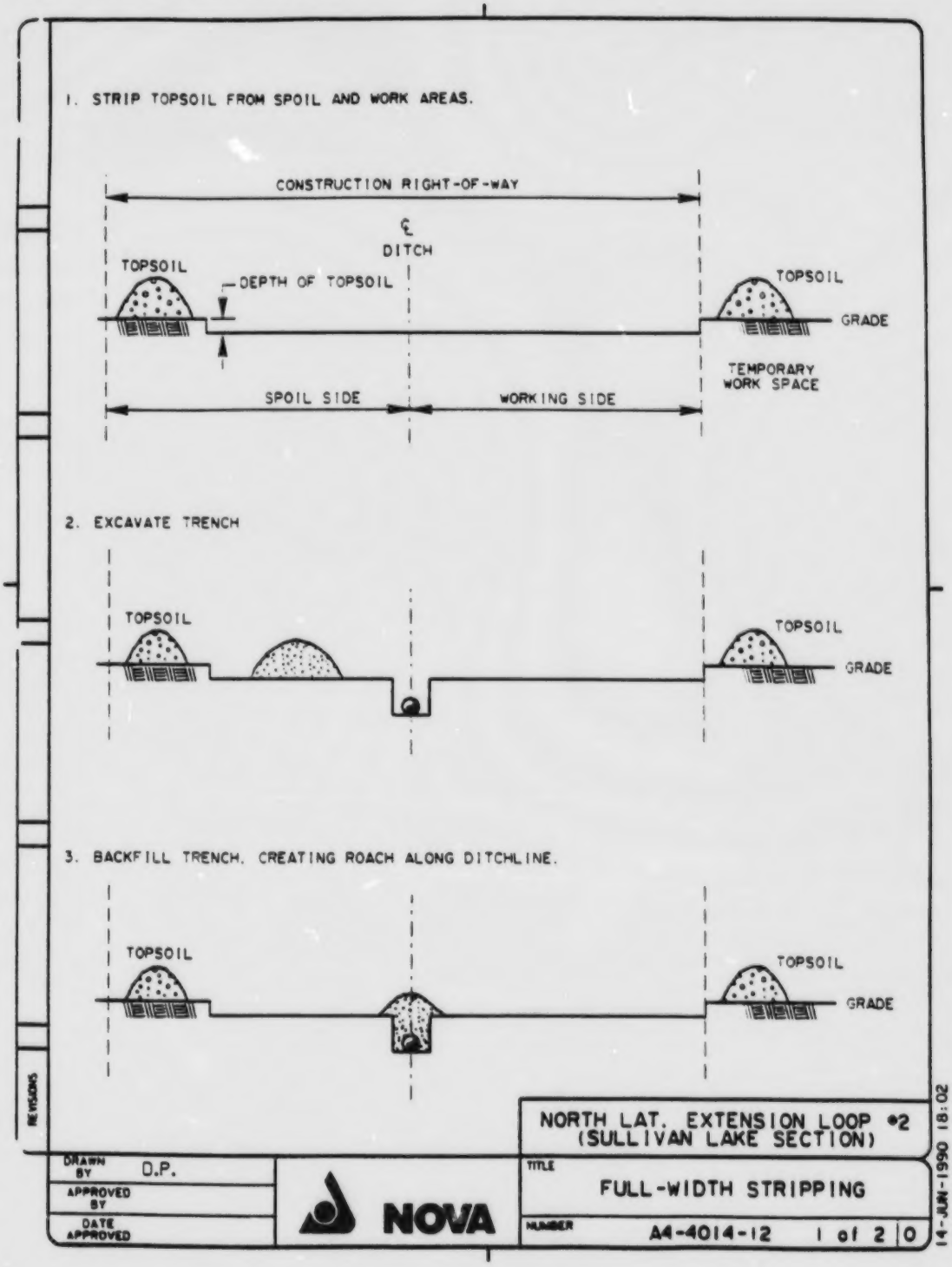


Figure 19. Topsoil Conservation in Brocket Soils

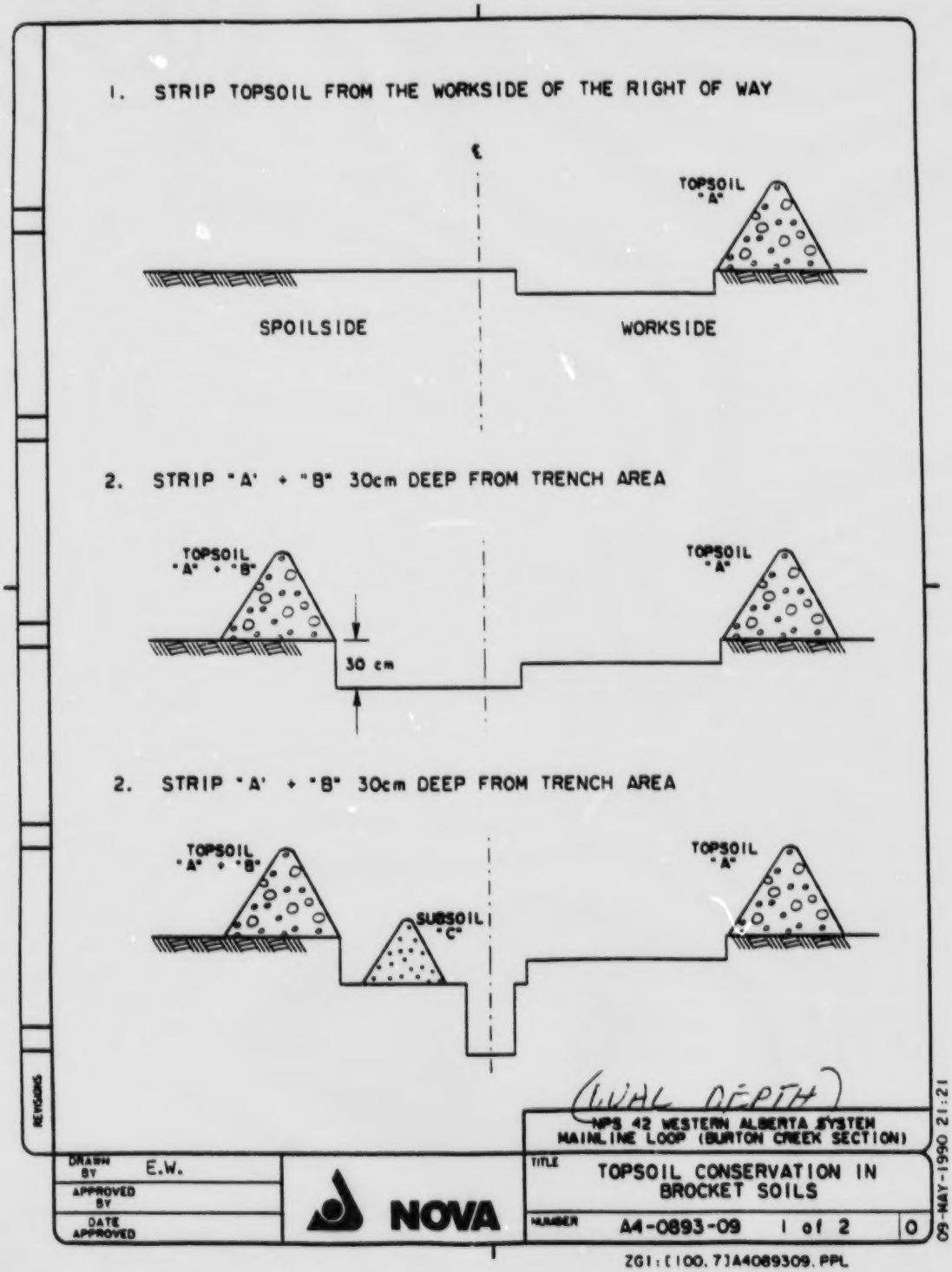


Figure 20. Topsoil Conservation in Brocket Soils

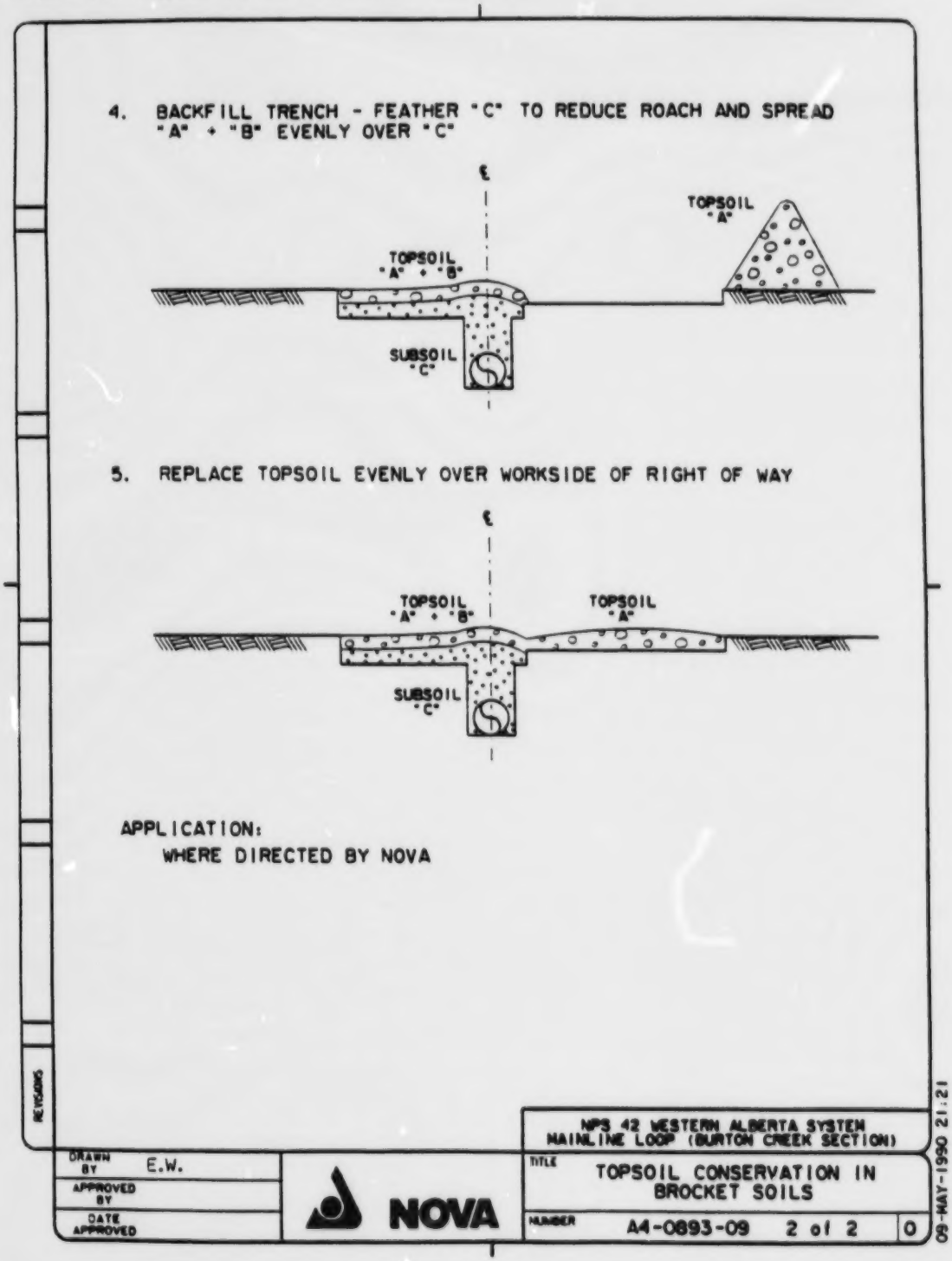


Figure 21. Full-width Stripping

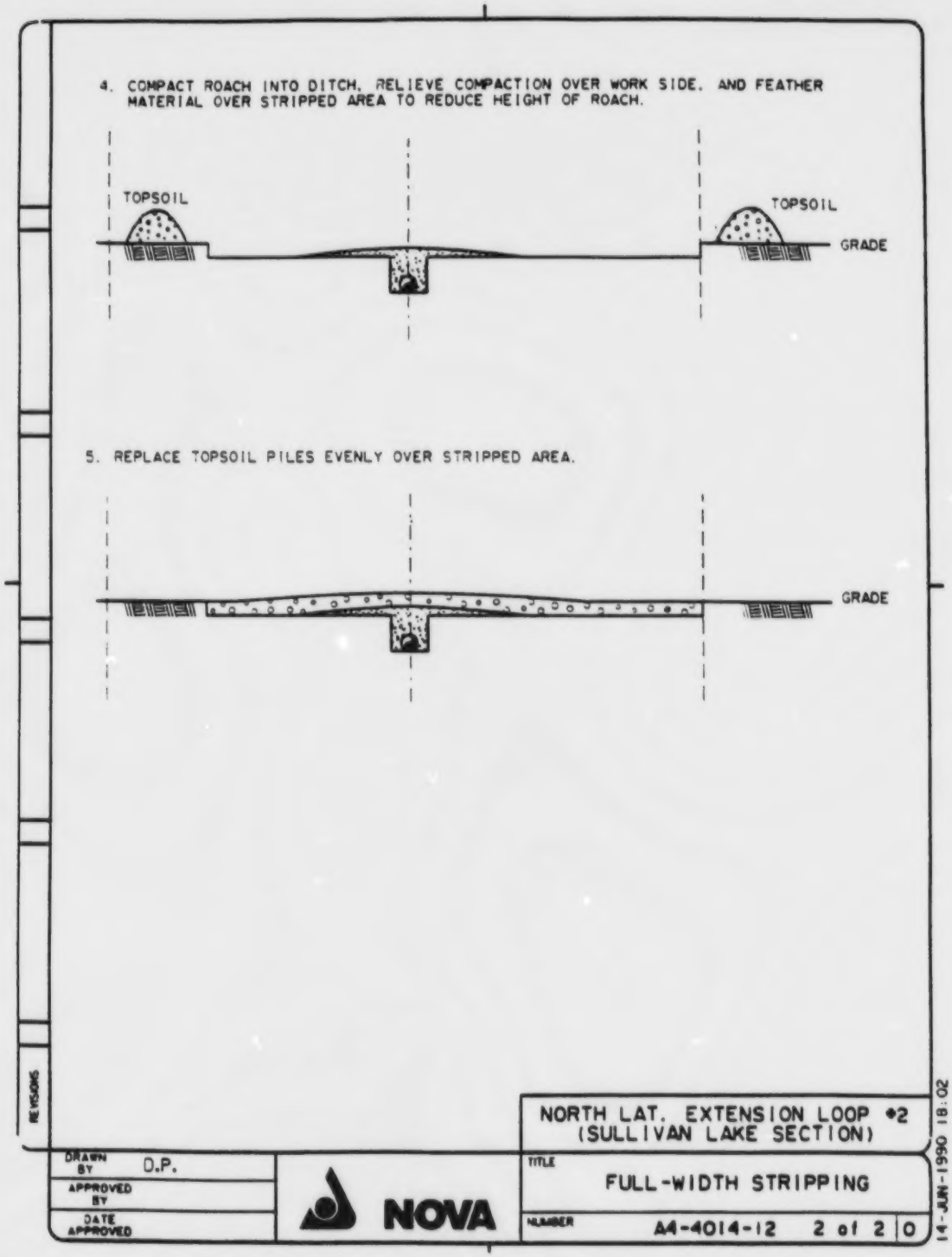


Figure 22. Trench Three-lift

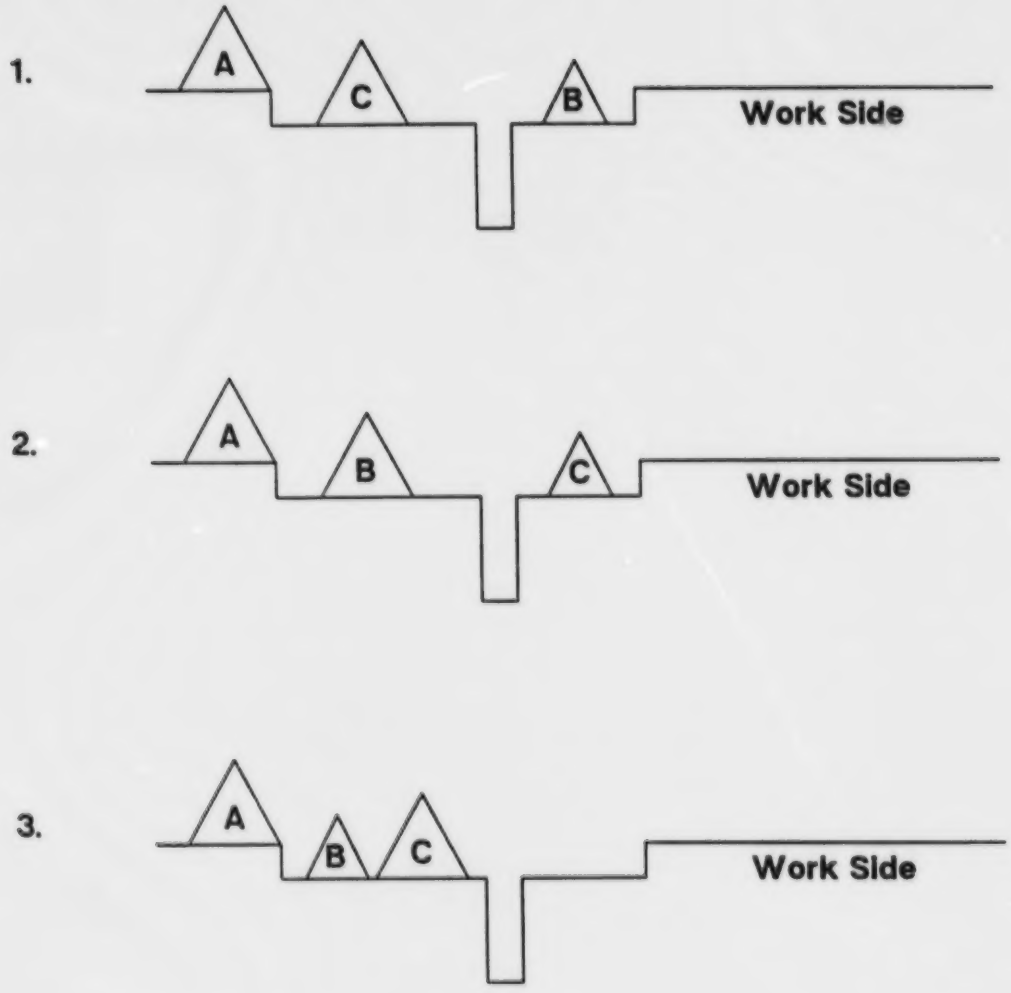


Figure 23. Three-lift Stripping NOVA P/L on Work Side

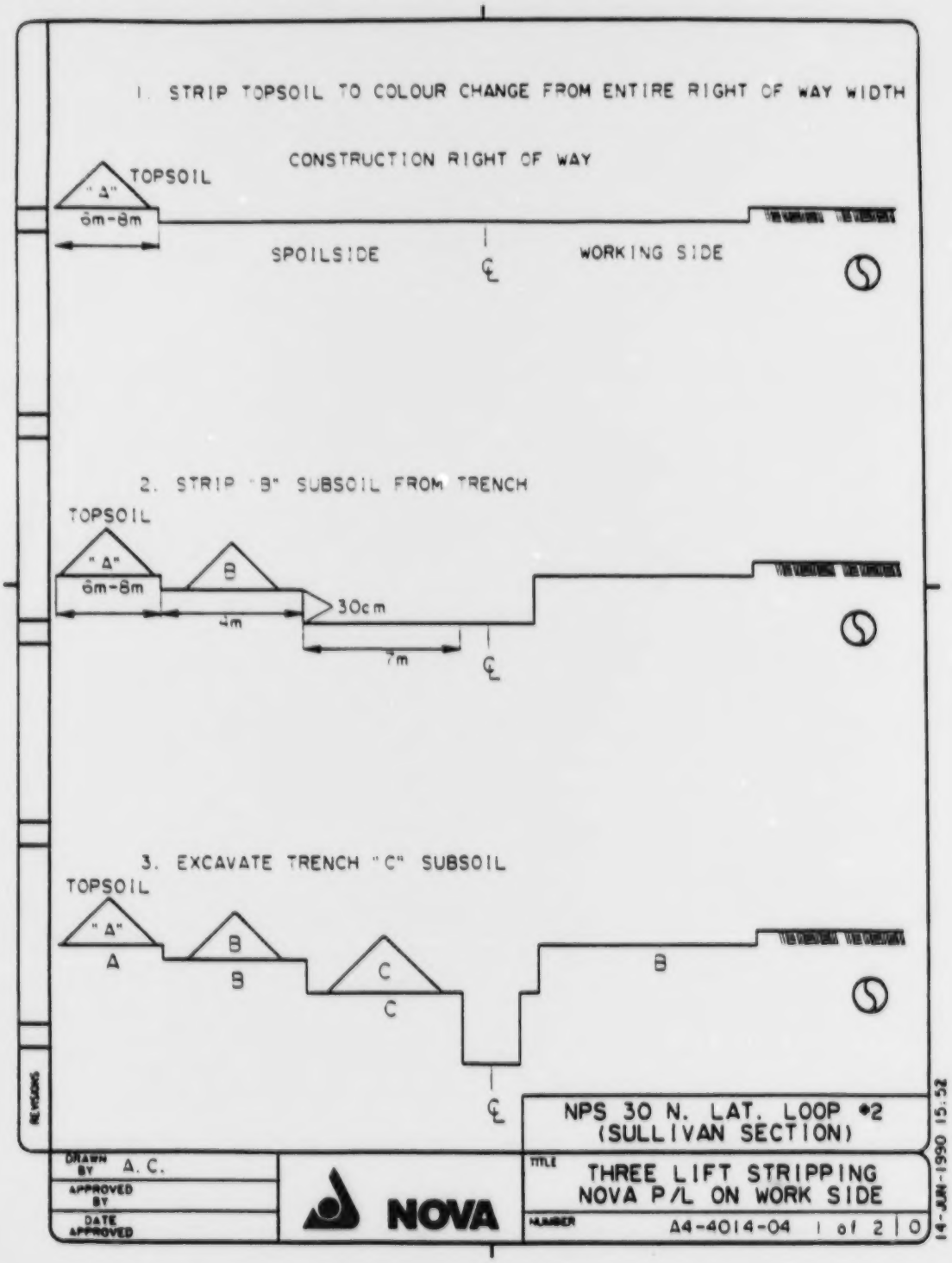


Figure 24. Three-lift Stripping NOVA P/L on Work Side

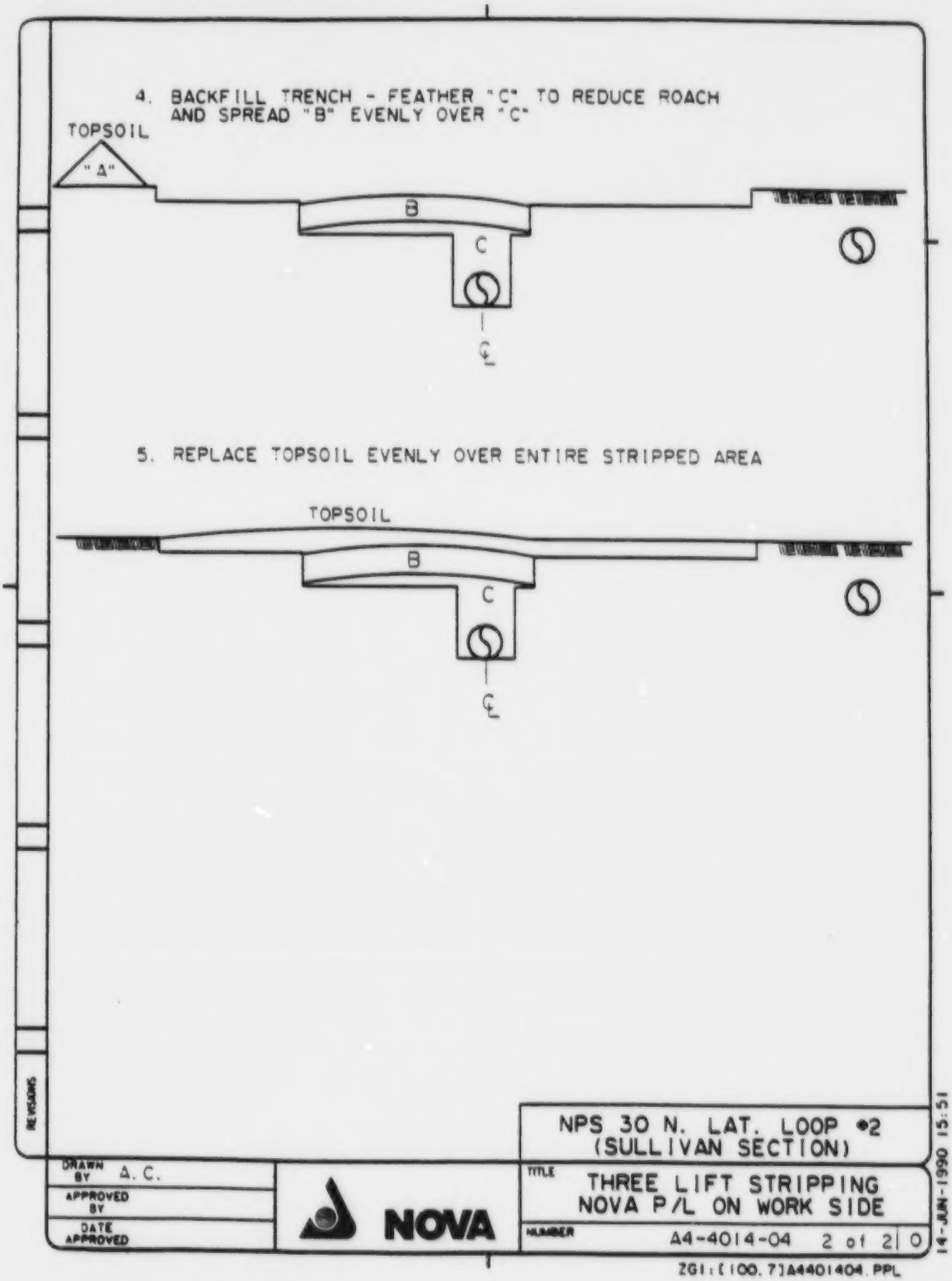


Figure 25. Three-lift Stripping NOVA P/L on Spoil Side

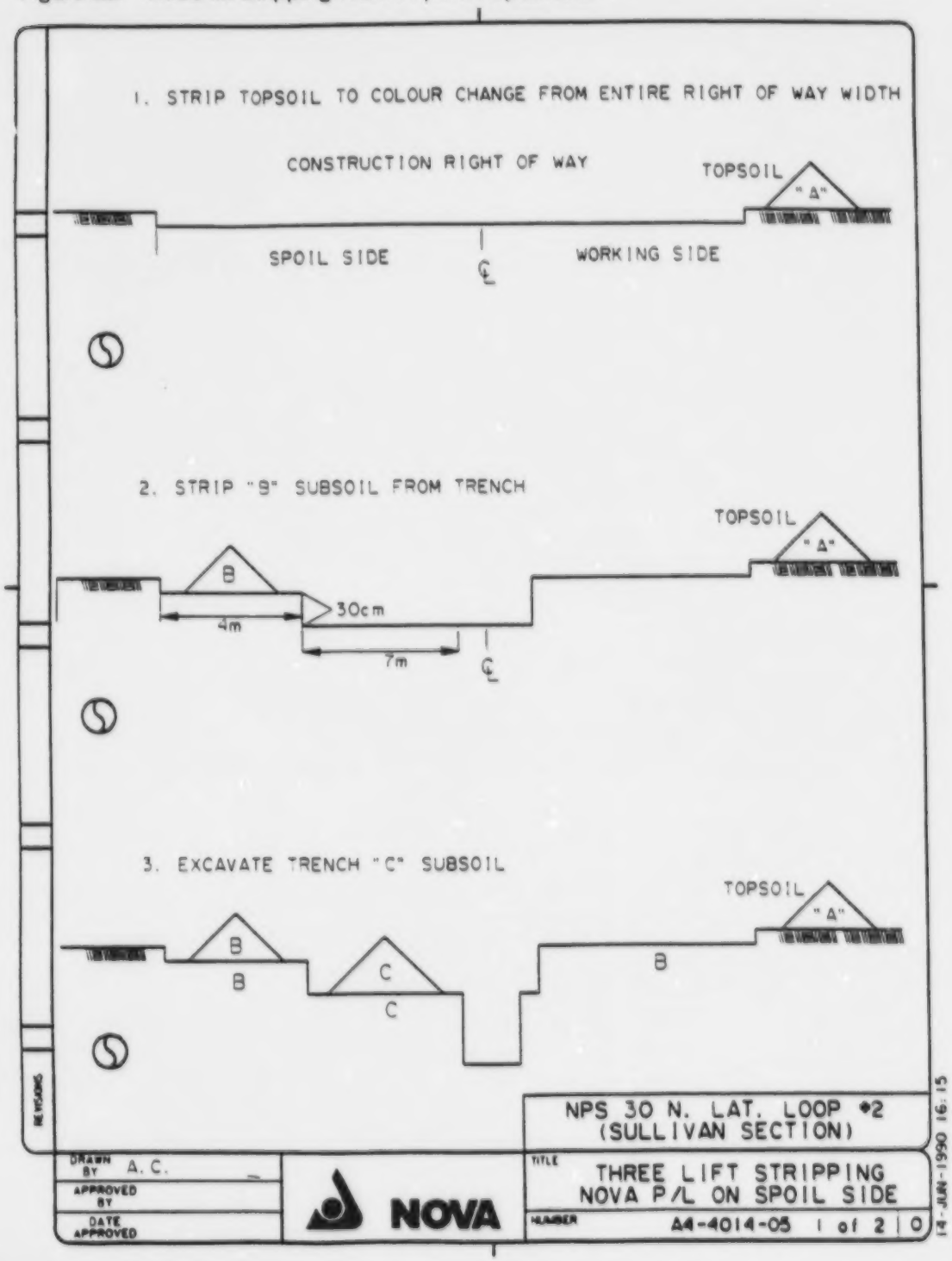


Figure 26. Three-lift Stripping NOVA P/L on Spoil Side

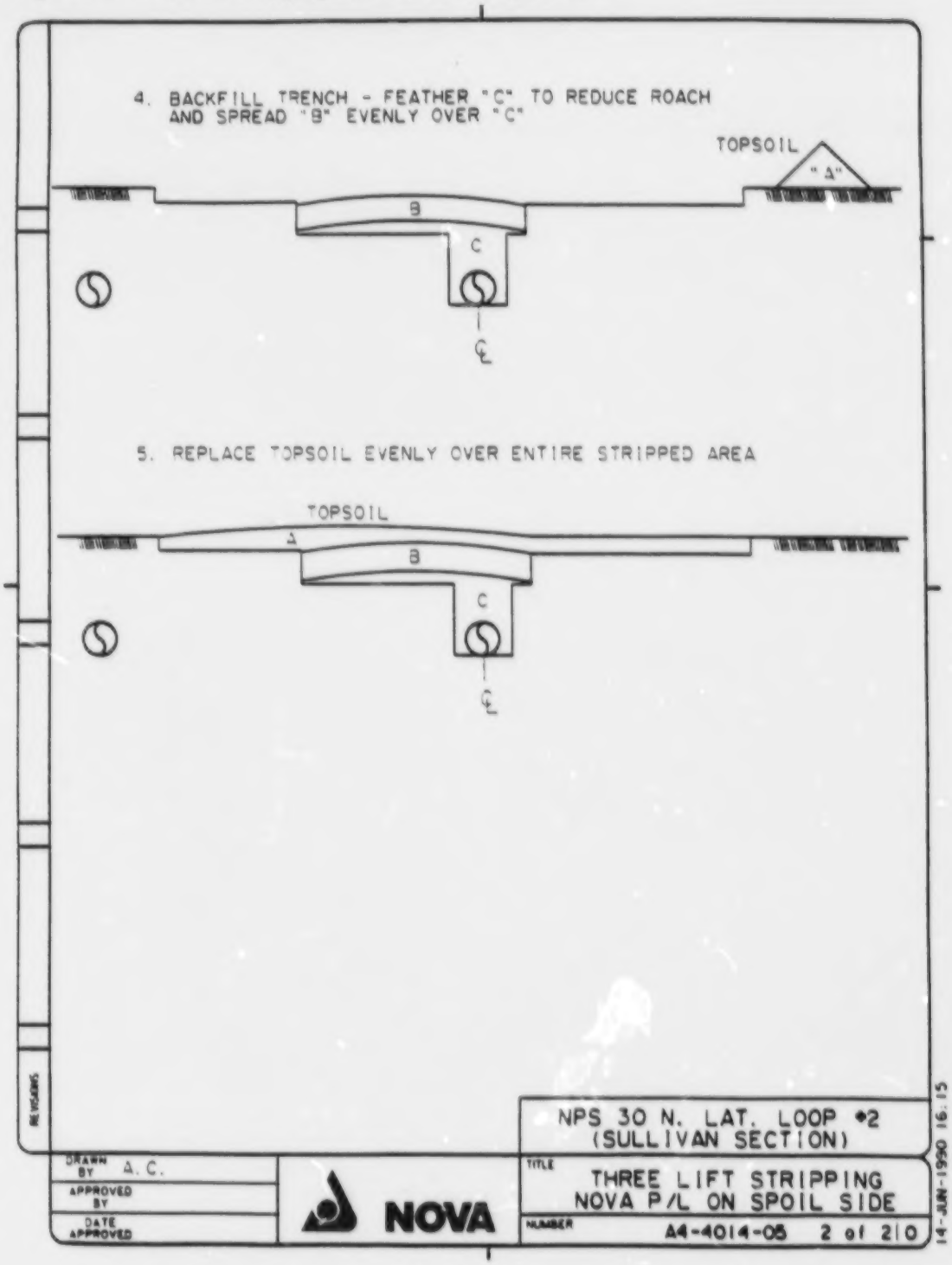


Figure 27. Three-lift Stripping Dusty Lake Section North Lateral Extension Loop No. 2

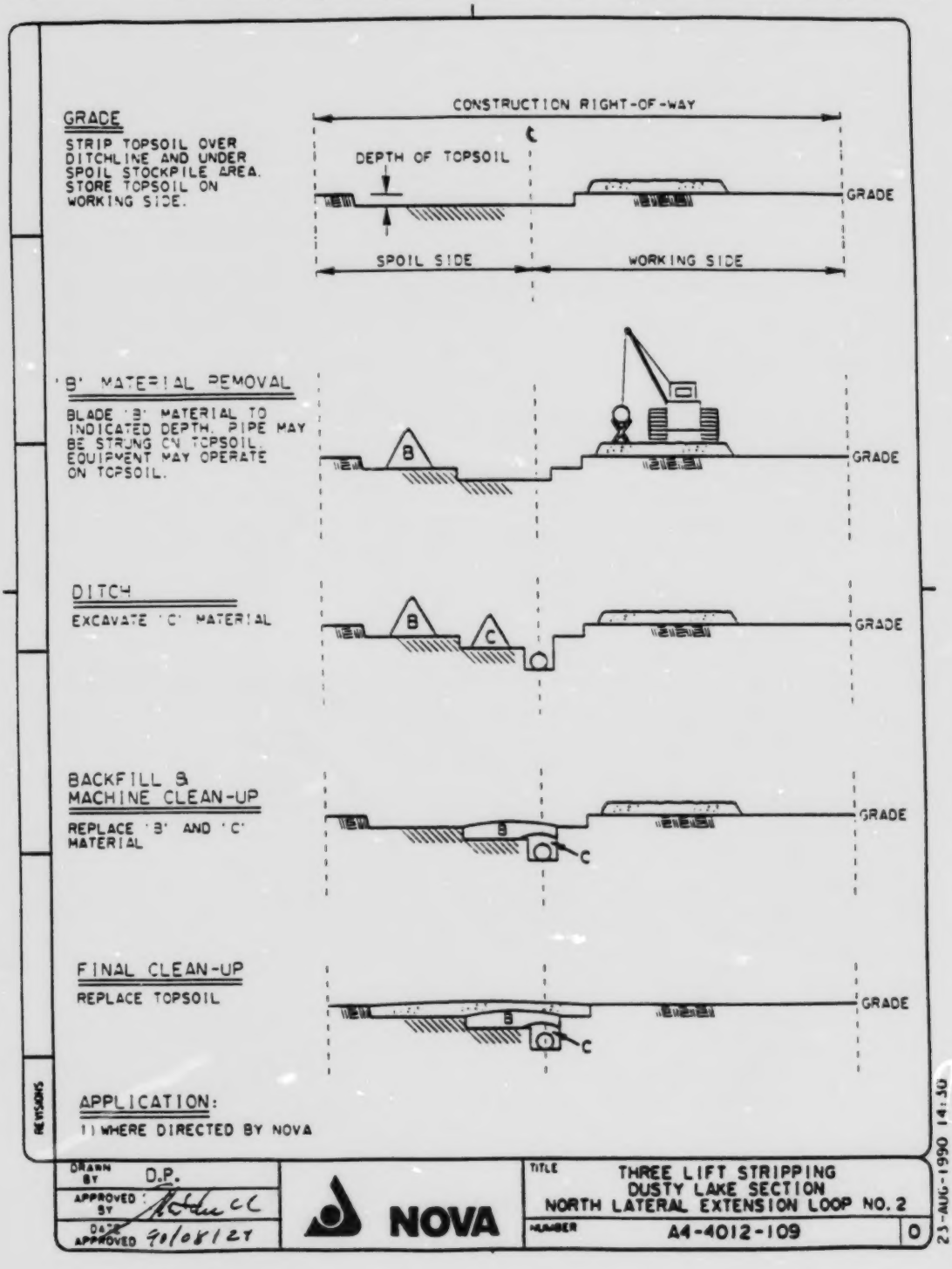
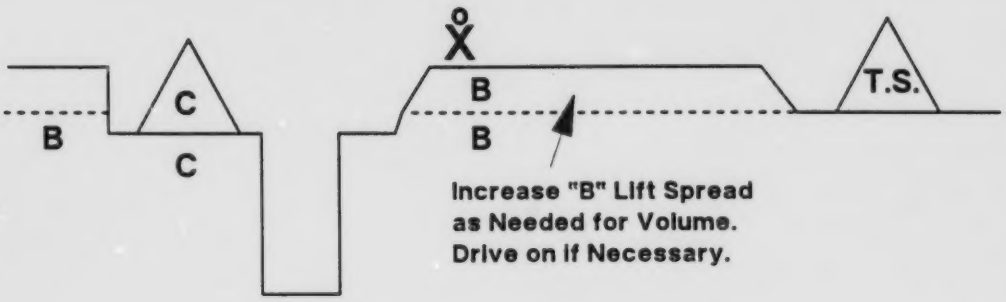


Figure 28. "Reduced Row" Three-lift for Full Width Stripping



Reduces Spoil Side Space, Brings Loop in Closer to Existing Lines. 4 to 5 m Total Width Reduction.

Figure 29. Option #2 Extra Depth Ditch for Two to Three-lift

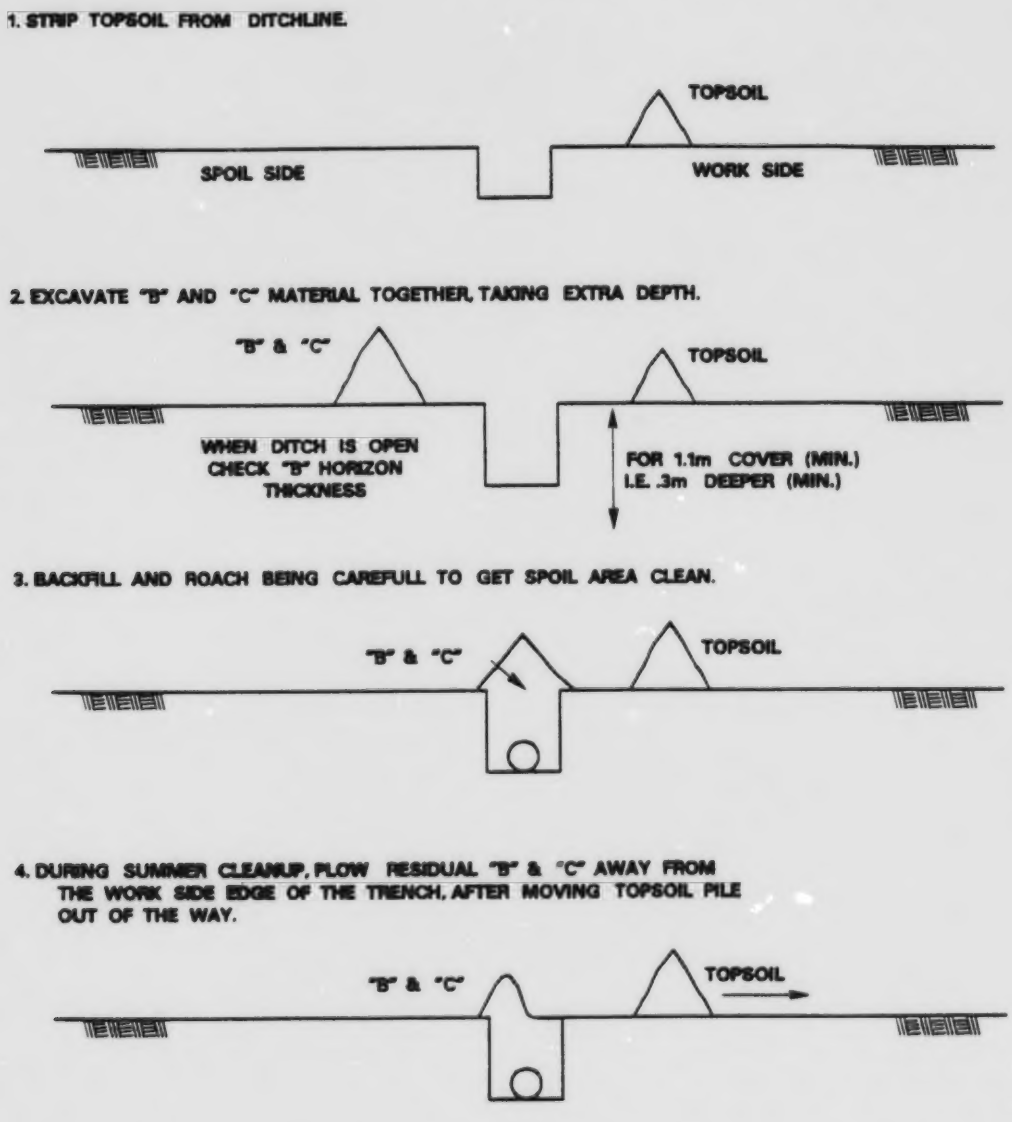
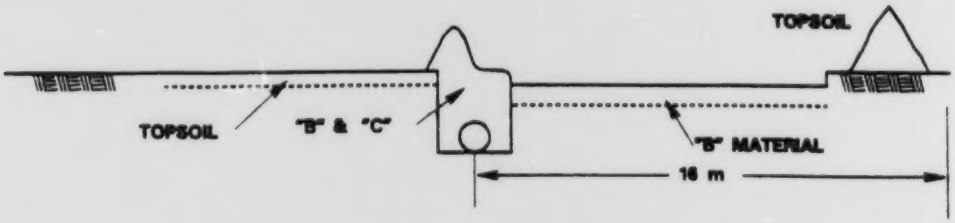
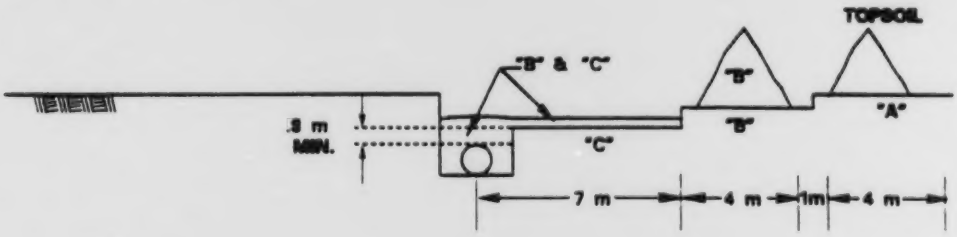

1. STRIP TOPSOIL FROM DITCHLINE.
TOPSOIL
SPOIL SIDE
WORK SIDE
2. EXCAVATE "B" AND "C" MATERIAL TOGETHER, TAKING EXTRA DEPTH.
"B" & "C"
TOPSOIL
WHEN DITCH IS OPEN
CHECK "B" HORIZON
THICKNESS
FOR 1.1m COVER (MIN.)
I.E. .3m DEEPER (MIN.)
3. BACKFILL AND ROACH BEING CAREFULL TO GET SPOIL AREA CLEAN.
"B" & "C"
TOPSOIL
4. DURING SUMMER CLEANUP, PLOW RESIDUAL "B" & "C" AWAY FROM
THE WORK SIDE EDGE OF THE TRENCH, AFTER MOVING TOPSOIL PILE
OUT OF THE WAY.
"B" & "C"
TOPSOIL

Figure 30. Option #2 Extra Depth Ditch for Two to Three-lift

5. STRIP TOPSOIL TO WORK SIDE EDGE INCLUDING DITCHLINE TOPSOIL, STARTING AT THE WORKSIDE EDGE OF THE DITCH.



6. STRIP "B" MATERIAL TO WORK SIDE MAINTAINING SEPARATION FROM TOPSOIL. FEATHER OUT "B" & "C" MATERIAL OVER STRIPPED AREA, ON TOP OF "C" HORIZON.



7. REPLACE "B" MATERIAL, THEN TOPSOIL.

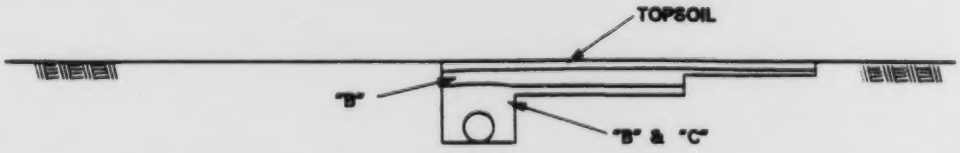


Figure 31. Three-lifts for Rocky Subsoils

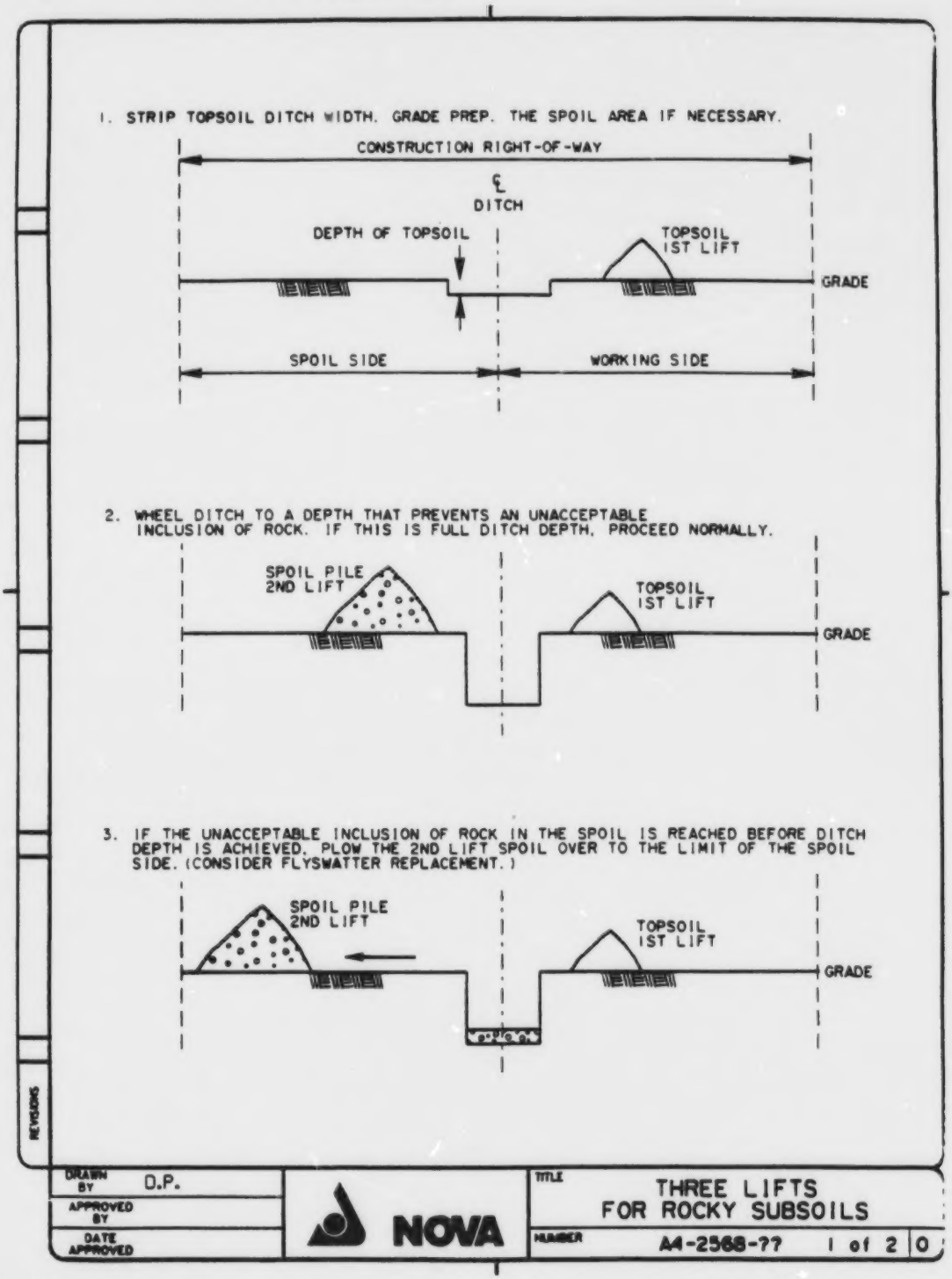
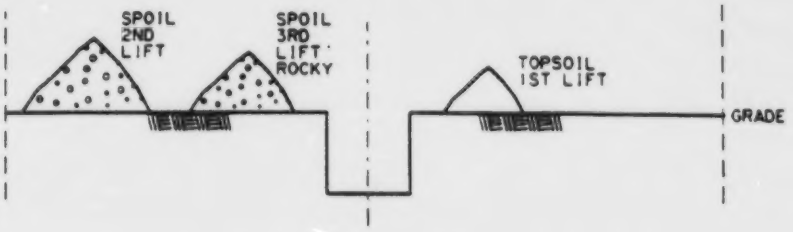
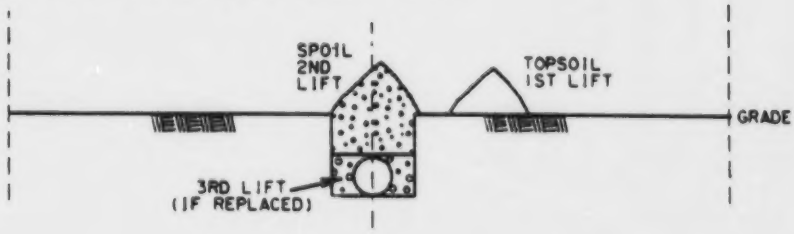


Figure 32. Three-lifts for Rocky Subsoils

4. REMOVE THE REMAINING ROCKY MATERIAL TO DITCH DEPTH AND PLACE ON CLEARED SPOIL AREA. WHEEL OR HOE MAY BE POSSIBLE.



5. REPLACE OR REMOVE ROCKY MATERIALS AS COMPLETELY AS POSSIBLE FOLLOWING PIPE INSTALLATION.
REPLACE 2ND LIFT AS COMPLETLY AS POSSIBLE. ROACH ON DITCH LINE TO GET FULL BENEFIT FROM SETTLEMENT IN SPRING.



6. CLEANUP IN SUMMER. STRIPPING ADDITIONAL AREA TO ACCOMODATE SPOIL VOLUME IF NECESSARY AS PER DRAWING A4-4013-03.

REVISIONS

DRAWN BY D.P.	NOVA	TITLE	THREE LIFTS FOR ROCKY SUBSOILS
APPROVED BY		NUMBER	A4-2568-77 2 of 2 0
DATE APPROVED			

20.	SOIL HANDLING METHODS FOR TWO-LIFT AND THREE-LIFT - QUESTIONS
Industry	I was focused when I arrived this morning, now I'm completely confused. We try to work on the idea of minimum disturbance; I see greater disturbance being planned here. Also, economics must come into play in the decision. (He gave an example illustrating an almost three-fold increase in potential costs per acre for installation.)
Industry	I agree.
Government	I'm not in a position to comment, that's a question for senior management.
Industry	You discussed the areas in the province requiring three-lift attention. It looks like about one-sixth of the province. We need to know the areas where it will be applied. I don't want to see the three-lift idea slipped in like this, and later find out it will apply to the whole province. Government should come up front on this right now if that is then case.
Government	I'm not sure of the areas you're meaning.
Government	It was the solonetzic map. We don't know how much area would require the three-lift technique, probably only a small area would be affected.
Government	Economics is an important factor, but it's not easy to deal with. We don't want to say that Government will back down on environmental standards at a certain dollar point. We would need to assess the impacts on industry and would need to do this at a senior government level. From previous experience (i.e., directional drilling), we've found that when dealing with new issues, industry can usually find ways of bringing the costs down.
Industry	I was not expecting Government to reduce environmental standards, just to be judicious in laying out these criteria. There must be an acknowledgement of costs.
Industry	There should be consideration of other environmental risks - greater period of time involved, the width of the disturbance, increased erosion. Also consider things like the additional fuel used, and additional CO_2 emissions if we want to use a holistic approach.

Consultant — It is my observation that the requirements of industry and government are not that far apart. We may have become confused by the discussion because of lack of knowledge. We should look at the discussion tomorrow as an opportunity to refine, and come together and see where to go on research and other needs.

Consultant — I see no difference in opinion in what the end result is to be. There are some questions - Can soil capability be measured by productivity; is productivity a factor? Farmers aren't concerned with E.C.'s and SAR's, but with whether the crop will grow. Do we need to address the idea of replacement cost versus reproduction cost? That is, to put it back to replace productivity, or just put it back like it was, no matter what the productivity will be?

The question is somewhat like a mosquito sitting on a pane of glass -- are we going to hit it with a sledge hammer?

Many of the problems that come up are due to disturbance. We are talking about possibly extra right-of-way, excessive construction activity, increased damage. On grassland, stripping will result in problems re-establishing native pasture, problems with cattle movement. I think we need to look at a zero-lift procedure!

Consultant — One question - have there been any studies undertaken on soil compaction in areas using three-lift procedures? This is an issue on wellsites.

Government — We did look at bulk density on the right-of-way, on the travel area and work area. We didn't see any compaction problems on the Standard Line, but construction conditions were good.

Industry — If implemented, the three-lift procedure could become the state-of-the-art, and landowners may start to demand it, and government may give in to landowners pressure.

Government — Giving in to landowners is not a practice we back. LCRC (Land Conservation and Reclamation Council) would not require three-lift on an area where it wasn't warranted.

21. DISCUSSION - WORKING GROUP 1

Group Participants

John Hermans - Chairperson	Alberta Agriculture
Chris Powter - Secretary	Alberta Environment
Howard Slavinski	Alberta Environment
Dave McNabb	Alberta Environmental Centre
Bob Seager	NOVA Corporation of Alberta
Wayne Marshall	TransCanada Pipelines
Donna Dowell	North Canadian Oils Limited
Al Twardy	Pedocan Land Evaluation Ltd.
Kathryn Bessie	Western Research

Initially, the group discussed what to start with, and what to focus on. Definitions were thought to require a short time; research will need to be focused carefully; interim guidelines will also need to be addressed.

The group decided that they would not discuss definitions as these would be addressed by the Steering Committee. Research items would be addressed as they arose, and about one hour would be devoted to point 2 on Interim Guidelines.

21.1 DISCUSSION ON INTERIM GUIDELINES

It is premature to have Interim Guidelines. There is not enough information to suggest that the three-lift procedure is required. There is a need for guidelines on the chemistry of three-lift. It was indicated that the industry guidelines seem reasonable. The role of Alberta Environment is to protect the environment/resource; it came into the guidelines at the request of industry.

It was indicated that there is a definite need for criteria, but there is also a need for statements of where they should not be used (e.g., in grasslands, conservation may be more important). It is necessary to balance three-lift objectives with three-lift impacts.

Once numbers are attached, then the requirements become more restrictive. The numbers are needed, but some subjective flexibility must be allowed. If the guidelines are too restrictive, the system won't work due to the natural variability.

Some concern was expressed regarding the science of how the guidelines were being used. Industry is nervous about how current guidelines are being applied. There is a need for more information on how this is done.

It was suggested that the guidelines should be applied only where the bottom layer is unsuitable. There was some discussion of the guidelines, and explanation that averages are not calculated (that was just an example). The comparison is actually between the upper subsoil and the lower subsoil. If they are one class different, then the three-lift procedure can be used.

There was discussion about whether the tables are good enough to interpret the use of three-lift. The concern was not necessarily with the tables, but with the one class difference. This is potentially too restrictive if it is actually applied. The question is, what alternatives are available?

It was suggested that a drop of two classes might be more appropriate. It was also suggested that possibly a new table specifically for three-lift would be most appropriate since it may be necessary to include modifiers for specific circumstances.

There was discussion of the 1985 guidelines. The 1985 guidelines don't need predictions of three-lift. Also, some of these jumps could actually be seen in the field. It was suggested that the 1985 guidelines would probably result in fewer instances requiring three-lift.

There is a need to consider climate and land use as modifiers, also thickness of the lift, bedrock type and thickness, texture etc. There was agreement that the concept of the 1985 guideline is good. Industry wants a guideline that is not interactive/subjective in most (say 80%) cases to assist in planning. The 1985 guidelines look at contrast between the B and C horizons, and there is a possibility of creating an A over B+C with wider spread. The numbers in the 1985 table may need adjustment. A subsoil depth factor may need to be added.

It was suggested that the real problem is the operational implementation of the plan.

The concept of three-lift as one method of material handling is acceptable.

Utilizing the soil series concept would help to take the climate factor into account.

There is a need for a set of overall objectives and goals for the three-lift process, and these must be practical.

Howard Slavinski (Alberta Environment) is working on a soils database. Pedocan is also developing a database (may be available at a cost) on soil series and material handling.

There is a need for more detailed work on three-lift areas before implementation, because sometimes implementation is based on data obtained from one test hole. It was suggested that it is possible to oversample an area to show that large blocks are really composed of smaller soil units. Therefore, it would be possible to break a three-lift area down into many small units, some not three-liftable. It was suggested that a map unit should be the unit of evaluation, not a soil unit or soil series. There was agreement on this point.

Consistency of procedures is important in avoiding problems.

There was agreement on using 15 cm as the minimum thickness for a lift. The question was raised as to whether there should be a maximum thickness for a second lift. Probably there should be a maximum, but there was no suggestion as to what this should be.

The group agreed that the existing criteria for assessing three-lift should be thrown out.

21.2 SOIL HANDLING AND CONDITIONING

It was suggested that in some cases the limiting factor (e.g., SAR) could be chemically amended. Therefore, a soil could be two-lifted and the whole soil chemically amended. In this case there must be a defined time period for the amendment to work, and a set of criteria for successful amendment would need to be established.

Alternative methods suggested included:

1. Plough-in (up to 6" pipe).
2. Narrow ditch/minimum disturbance (for <18" pipe).
3. Boring (not economical).
4. Two/three-lift for winter (see Appendix 19).
5. In gravel, two-lift, but screen gravel.

6. Overstripping.

7. Above-ground pipe.

There would need to be discussions on pros and cons of each, and evaluations of the merit of each. Research may be needed. There was discussion of the possibility of improving the topsoil quality to offset the loss of subsoil quality, but this idea was rejected because government may not accept the idea.

21.3 RESEARCH

There seems to be lots of opportunity to do post-construction monitoring to provide data.

There was still the question of why there is a problem with mixing contrasting layers, and the impacts on soil quality. Research is required, in the field, to determine if there is any significant difference in the two-lift and the three-lift process in final soil capability.

Research must be jointly funded, managed, and designed. Control of the research method is, in some cases, critical to the success of the method. This must be kept in mind in designing any research project.

There is a need to look at the question of ROW width, and how it is affected by the material handling procedure.

A concern was raised on sampling to depth on top of a hot pipe. This is not a concern with hand sampling.

It could be possible to study a set of pipelines of various sizes in a "controlled" research area. There was discussion as to whether existing pipelines could be used for research, or whether only new lines should be studied. With existing lines it is possible to get an idea of whether a problem exists, but information is often not available on weather conditions, implementation practices during construction etc. for existing lines.

Possibly a survey of recent lines (since 1980) could be undertaken to evaluate concerns/successes by soil series (as compared to off-ROW control). The focus should be on potential three-lift soils, looking at the trench, work side and spoil side. It may be possible to undertake other projects at the same time as this survey.

New pipelines could be monitored to evaluate the success of the approved materials handling procedures. This would help to build an industry-wide database.

Monitoring could become part of the approval process. Preliminary work is needed to develop monitoring criteria and standard procedures. It may be necessary to limit the number of new lines per year per company required for monitoring.

The 1985 guidelines could then be evaluated based on the research and monitoring (as an ongoing procedure). Such modifiers as minimal disturbance on dry grasslands should be evaluated.

22. DISCUSSION - WORKING GROUP 2

Group Participants

Mike Houser - Chairperson	NOVA Corporation of Alberta
Travis Ferguson - Secretary	Alberta Environment
John King	Alberta Environment
Terry Macyk	Alberta Research Council
Harry Lillo	ERCB
Stewart Lunn	PanCanadian Petroleum Ltd.
Herb DeMars	Mobil Oil Canada
Linda Postlewaite	NOVA Corporation of Alberta

The group decided to discuss the topics in the following order:

1. Definitions.
2. Guidelines.
3. Research.
4. Alternatives.

22.1 DEFINITIONS

Disturbance. The government position is that the disturbance definition is not inclusive, in that government needed to focus on three-lift, not minimum disturbance. It should be noted that three-lift is not independent of disturbance.

Equivalent Capability. There are a range of properties within classes (either Soil Quality Criteria or Land Capability Classification). The industry position is that three factors, land use, capability, and productivity, form a part of the definition of equivalent capability.

It was indicated that the government approach is broad because the definition must relate to all surface disturbances.

Suggestions included evaluating capability in the pre- and post-disturbance states; using productivity instead of capability; relating productivity to capability classes. (The latter could be a research topic.)

There is a need to define Equivalent Capability versus Capability. Another opinion was that this is not necessary since land use is given.

There was no consensus on this topic. Industry wants to relate productivity to capability; this is unacceptable to government - wants to use capability.

Soil Quality. Needs clarification.

In summary, the discussion indicated that productivity and capability are related. Minimal disturbance needs to be addressed.

22.2 INTERIM GUIDELINES

The discussion was focused on four needs:

1. Where - soil properties.
2. Length.
3. Depth.
4. Materials handling.

Discussion indicated that three-lift should be considered based on E.C., SAR, SAT%, pH, and texture. Soil series information should be utilized. Using equivalent (need definition), when it is not possible to achieve equivalent capability with two-lift soil handling, there is a need to look at alternatives like three-lift. Alberta Environment says that three-lift is not CLI class dependent. Industry indicated that only upper CLI classes should be considered for three-lift.

Discussion of length indicated that the soil unit on the map should be used.

Depth should be considered depth to unsuitable material. Both a minimum buffer depth and a maximum depth should be considered.

Materials handling should address optimal procedures to minimize total impacts.

Alternatives for winter versus summer should be addressed.

22.3 RESEARCH PROPOSALS

It was suggested that initially, existing information such as the mining research should be made use of. From this point, a pipeline database should be developed. The database should include:

1. As-built reports.

2. Pure research on:
    a. productivity versus capability,
    b. depth to poor quality,
    c. depth to replacement,
    d. overstripping,
    e. amendments,
    f. disturbance width,
    g. B/C mix ratios,
    h. location of problem soils,
    i. equipment developments.

For monitoring to be focused, there is a need to clarify positions to define research needs.

22.4 ALTERNATIVES TO THREE-LIFT

Alternatives include:

1. Overstripping.
2. Management of two-lift over time without amendments.
3. Incorporation of displaced B/C mix into spoil area.
4. Operator skill level (i.e., equipment specifications) in instances of trench/pipe tight fit, ploughing, drilling, boring, and using the right equipment.
5. Removal.

23. DISCUSSION - WORKING GROUP 3

Group Participants

Al Scheibner - Chairperson	Western Oilfield Environmental Services Ltd.
Rob Staniland - Secretary	BP Canada Inc.
Doug Beddome	Alberta Environment
Larry Brocke	Alberta Environment
Alan Cassley	ERCB - Pipeline Department
Al Fedkenheuer	NOVA Corporation of Alberta
Dave McCoy	Husky
Glen Stalker	Northwestern Utilities Limited
Jean Crepin	Norwest Soil Research Ltd.

23.1 DEFINITIONS

D&R. Definitions will change

Disturbance. The issue of minimal disturbance is not an issue.

Economics. Not under consideration.

Extent of Disturbance. This definition is OK. The last sentence should be deleted.

Three-lift. CPA version accepted.

Soils for Three-lift. Two typical conditions were accepted.

Two-lift. Topsoil/subsoil - CPA

Comparisons. Delete this definition.

Correct Procedure. Delete this definition.

Topsoil Replacement. Topsoil conservation is presumed.

Subsoil. Subsoil is subsoil.

Return of Security. Delete this definition.

Capability. CPA definition should be amended to read "Ability of soil to sustain a variety of land uses".

Soil Quality. A rating based on chemical and physical characteristics.

Productivity. The measure of performance of a land unit.

Soil Conservation. First sentence of AE definition.

Soil Survey. Not relevant to the discussion.

23.2 INTERIM GUIDELINES

Interim Guideline - 1. Are the existing criteria valid?

The unit boundaries are too arbitrary in terms of small changes. There was a preference expressed for the 1987 (Pettapiece) system. There was a criticism of the interim guidelines for not allowing for consideration of the relative importance of various factors. One member pointed out that the interim guidelines are based on the most limiting factors. The consensus was that the first criteria has weaknesses.

What is needed is a system which considers all aspects of soil capability and degree of change. Needs more flexibility than the existing system. This system should consider factors such as ecoclimatic considerations, landscape, hydrology, and the relative importance of the factors.

There was agreement that part one was presumed not to preclude alternative methods.

Interim Guideline - 2. It was suggested that this should read 50% of the unit. This was desirable since if using the number of site inspections, the sample could possibly be biased to the more variable/questionable areas of the unit. It was agreed that there is a need to interpret the extent of the problem within the unit, and this is not necessarily based on the number of samples.

Interim Guideline - 3. Concern was expressed as to whether the 15 cm makes a difference. The thickness should be a consideration under point 1 in the context of the degree of change and ecoclimatic considerations. Equipment limitations are a separate issue.

Interim Guideline - 4. Should be reviewed and adapted.

23.3 HANDLING ALTERNATIVES

The alternatives suggested included:

1. Rerouting.
2. Boring.

3. Narrow ditching.
4. Ploughing.
5. Overstripping.
6. Amelioration.
7. Cultural (especially vegetative cover).

23.4 RESEARCH NEEDS

Research is needed to determine the effect of mixing various proportions/types of subsoils on the resulting quality of the soil. It was indicated that SAR, E.C. etc. respond differently in different soils, the relationships are not linear or directly proportional.

An inventory and assessment on old lines should be conducted to investigate the time effect.

As-built monitoring could also investigate the time effect, and compare alternative existing construction techniques.

There is a need to reduce variability and make monitoring and assessment meaningful. Issues such as the time of sampling, conditions of sampling (i.e., weather/ cultural) need to be addressed. There was consensus on this.

There was a difference of opinion on whether existing information is sufficient to "classify" quality.

24. DISCUSSION - WORKING GROUP 4

Group Participants

Roger Creasey - Chairperson	ERCB - Environmental Protection Department
Colette Cloutier - Secretary	NOVA Corporation of Alberta
Arnold Janz	Alberta Environment
Roshan Grover	Alberta Environment
Wayne Tedder	Alberta Forestry, Lands and Wildlife
Gary Mott	Bow Valley Industries
Len Knapik	Pedocan Land Evaluation Ltd.
Dave Paton	Crossfield Laboratories (1987) Ltd.

24.1 DEFINITIONS

Three-lift. One topsoil layer and two subsoil layers. Should also mention that the soil has subsoil layers of contrasting physical and chemical qualities.

Two-lift. Handling the soil in two-lifts - one topsoil and one subsoil.

Topsoil Replacement. Removing, stockpiling and replacing the topsoil.

Subsoil. All soil below the topsoil.

Return of Security. Doesn't apply here.

Soil Capability. There is lack of a clear definition.

Soil Quality. The quality of the soil refers to its value as a substrate for sustaining plant growth. There is a need for a rating system that rates the entire soil versus just rating soil horizons.

Productivity. One measure of soil performance.

Soil Conservation. Stop after factors in definition.

24.2 INTERIM GUIDELINES

We are talking about equivalent capability, not preservation. There is a need to predict soil quality and capability upon mixing. Industry would like to see a set of accepted soil handling techniques for individual soil series; government doesn't object to this.

Comments on the Interim Guidelines were as follows:

1. The Guidelines do not predict a mix for post-construction soil quality.

2. Topographic and climatic conditions in Alberta are not included.
3. Item 2 - Need recognition of sampling needs to address soil variability.
4. Item 3 - This item is site specific.
5. There is a concern with the appropriateness of the 50% criteria in the second point. Some thought it should be 25%; some thought at least 50% of the map unit (not site inspections).
6. Everyone accepted and agreed to Item 4.

24.3 ALTERNATIVE SOIL HANDLING

The following alternative soil handling methods were suggested:

1. Overstripping may be an alternative to three-lift in some situations. In Brown Chernozems this may not be appropriate.
2. Plough-in, although it may have limitations due to stoniness etc.
3. Chemical amendments.
4. Rerouting.
5. Depth to cover.
6. Narrow ditch.
7. Horizontal drilling.
8. Minimum ditch width.

24.4 RESEARCH NEEDS

Research requirements identified included:

1. Improvements in soil handling equipment.
2. Improvements in ploughing equipment.
3. Investigate chemical amendments to control B and C mixing problems.
4. As-built reports required by NEB could provide useful information, possibly in determining the magic number for time to change. It was suggested that a database could be set up.

24.5 RECOMMENDATIONS

Set up a Task Force to review and establish criteria. Industry is not prepared to accept the guidelines as they are in the meantime, as suggested by government. All parties agree that there is a need for improvement, but not for complete rejection of the guidelines.

25. DISCUSSION - WORKING GROUP 5

Group Participants

Dennis Bratton - Chairperson	Alberta Environment
Jim Lore - Secretary	Jim Lore & Associates Ltd.
Bob Onciul	Alberta Environment
Sam Takyi	Alberta Forestry, Lands and Wildlife
Fred Kuipers	Peace Pipe Line Ltd.
Tim Bossenberry	Interprovincial PipeLine Company
Rob Durward	Enpro
Len Leskiw	Can-Ag Enterprises Ltd.
Hank Vander Pluym	Alberta Agriculture

There was discussion of the requirement to use judgement in the analysis (especially in the grey area). There shouldn't be such sharp lines determined by mathematical calculations as to what is suitable or unsuitable. The variability observed is partly due to how and where the sample is taken.

25.1 SOIL HANDLING ALTERNATIVES

Alternatives exist to address the concerns raised by the three-lift approach. These include:

1. Minimum stripping will reduce impact, normally a wide right-of-way is needed to feather topsoil.
2. Rerouting pipelines to align with roads was mentioned, but is likely not feasible since this would limit road development.
3. Winter construction was suggested.
4. Ploughing in with two to three passes is a possibility.
5. Amendments are possible, but generally need moisture to leach out salts.
6. Time and moisture will solve salinity problems, especially if lime is applied.
7. Snow fencing the line could improve moisture retention to increase leaching, along with the heat of the line.
8. Crowning of the line could result in water running off the line. This may therefore be an undesirable practice, but landfarming the extra material to

get rid of the crown has merit in some soils. (It is recognized that this must be done with care, and might require regulation.)

9. Leave the trench depressed slightly to catch water and aid leaching, but this must be done with care to avoid water erosion.

10. In some cases vegetation could be used to open up the soil.

There are two main objectives, to keep disturbance down and maintain soil capability. Industry is not convinced that three-lift is necessary. Industry is also not convinced that there is a problem in the first place.

25.2 INTERIM GUIDELINES

It is felt that the sampling procedure and the lab procedure are still evolving, but is, as yet, not accurate enough as a basis for the three-lift requirement. It is recommended that detailed sampling be undertaken to determine if there truly is a problem in a particular case. This would be much more economical than applying the three-lift technique in every case meeting the criteria.

It was suggested that, in the meantime, we should err to the conservative side since this is a grey area which needs to be addressed.

It was suggested that the big push on construction of regulated pipelines is over for a few years. Since there are many questions about the process, it should be studied in the interim, and in the meantime there should be a moratorium on the three-lift procedure. The group was not unanimous on this point.

There was some difference in opinion in the applicability of the first point. Some participants thought it was acceptable; others thought it was applicable for gravel and bedrock, but not good for sodicity. There was some opposition to the idea of the use of a boundary for soil capability classifications.

A need was identified to review the three-lift criteria. This should be done by a combined industry/government/independent consultant group. This process should be undertaken between now and March, since no potential three-lift pipelines will be constructed before that time. Another opinion was that industry should make a presentation of their position to government. A third opinion was that any study should be undertaken independent of industry or government.

25.3 RESEARCH PROPOSALS

There is a need to study whether the three-lift process creates problems, while trying to solve others, one aspect being whether the increased disturbance outweighs any benefits.

Research needs to be done to determine whether the three-lift procedure improves capability.

There is a need to determine whether productivity can be used as a measure of success.

There is a need to research whether salts move in the pipeline trench, the conditions under which they move, and the time frame.

A suggestion was made to select 10 to 12 sites on which three-lift has been carried out, over various land uses, and compare with similar two-lift situations. This study should include:

1. Salt movement.
2. Economics.
3. Surface soil disturbance (width/quality).
4. Productivity.
5. Energy inputs.
6. Hazards of erosion.
7. Land farming.
8. Compaction.

This study should be undertaken over a two to four year period. Another approach would be to look at pipelines which were done with two-lift, which would now require the three-lift procedure.

Other research topics included identifying the organic matter content which is desirable for overstripping; and research on appropriate ditch width fitted to pipeline size.

26. CLOSING COMMENTS - QUESTIONS AND ANSWERS

Industry — There is a lack of trust in the two groups. This is unfortunate. The perception of both sides was apparent from their presentations - industry showed us some of the most perfect photos I've seen; the government slides showed cases that were a real mess. The truth is somewhere in between.

In reality, this is not a big issue. We can see other effects on soil that are far more serious, and government would be much better directed to address these. Those in government who address soil problems with pipelines are well intentioned, but they should keep things in perspective.

Government — I would agree with the industry comments. This is not a big problem in our (Public Lands) mind. Our attention could be well spent in other areas.

Industry — The soil map unit was brought up as a handling length. Does the soil series have any application to apply to three-lift as a planning tool? Could one of the soil specialists present comment?

Consultant — The soil map series can be used to provide a handle on the soil's properties and abilities. There is a need for a recommendation on what to do with each. One approach would be to look at what has been done on similar soils and use this information to assist in decision-making.

Government — I would echo the first comment, especially on trust. We need more communication. There is a need for open discussion such as this forum to resolve issues.

Industry — The issue may not be insignificant. We need more information as a planning tool. We don't want to discover later that a lot of reclamation is required because of what we didn't know at the time of construction.

Industry — I'm not implying that there is no problem with pipelines. Three-lift, though, is not necessarily the solution to all the problems. Funds should be used to address other issues.

27. CLOSING COMMENTS - INDUSTRY - IAN SCOTT

At the beginning of this workshop there was trepidation on whether this would be successful. From what I've seen, it has been successful. I've heard a lot of interest here. The question of trust is a good one. We don't want to be fighting each other all the time. The Alberta Pipeline Environment Steering Committee (APESC) should be able to assist in this process.

The key between industry/government/companies and individuals is communication. This forum aids communication. This forum is not the end of the process. It is unfortunate that it didn't take place eight years ago.

We have received a set of Interim Guidelines from Alberta Environment. These are something to work from.

The question I ask is, if we do this again who should be here? Should we include surface rights groups, equipment manufacturers, or contractors - they all play a part in determining limitations.

Industry is moving to be more receptive to three-lift. We're not just digging in our heels. We're saying that there are instances where it may be appropriate, but we must also explore available alternatives.

There is an information gap that needs filling. Funds to do this will have to come from both sides. We need clean operating procedures and assurance that what is planned is actually occurring. There is a need for better inspection for both data gathering and conformity. APESC will be addressing this issue.

There is general agreement that government needs to look at the Interim Guidelines.

The definitions, which we have looked at, are a problem, and everyone agrees they need work. They were prepared as a basis to work from. Industry and government need to sit down and refine them.

Industry is prepared to provide funds for research where needed. Industry wants a consultative process in order to have input into the guidelines etc. We don't like surprises.

In summary, we should not look to the past. We did some things wrong. What we must do now is build trust and work forward. This will come through communication. As one participant said, we are not far apart. The next step will be a major step for both industry and government.

28. CLOSING COMMENTS - GOVERNMENT - JOHN KING

Speaking second is a problem in this case, since Ian stole all the comments I was going to make. This indicated the degree of cooperation and communication that occurred in the workshop -- we're both saying the same thing.

There was a need to get the positions of both sides out. This was not always positive, but it had to happen.

We set up a situation where both sides could come together for a workshop, and progress was made. If we had some more time here, I believe that very real progress, and resolution of issues could have resulted. I would like to see the discussion group process repeated, to provide for continuation of the process.

The amount of preparation on all parts for the workshop was obvious, and I commend everyone for this.

The question is, how to take that next leap forward? It can be done. We will take the suggestions forward to APESC. The Task Force may also do some work, including review of the Interim Criteria for changes in the three-lift specifications and the research requirements, to work towards resolution. Research items could also be directed through RRTAC or the Task Force. I will be making a presentation to API/GEC on December 20.

Regarding the Interim Guidelines, every group suggested modification. I feel both sides would agree to modification of these. We need a joint effort on these topics, and I hope that we can move forward together from this point.

29. WORKSHOP PARTICIPANTS LIST

Name	Company
Doug Beddome	Alberta Environment
Kathryn Bessie	Western Research
Tim Bossenberry	Interprovincial PipeLine Company
Dennis Bratton	Alberta Environment
Larry Brocke	Alberta Environment
Alan Cassley	ERCB - Pipeline Department
Colette Cloutier	NOVA Corporation of Alberta
Roger Creasey	ERCB - Environment Protection Department
Jean Crepin	Norwest Soil Research Ltd.
Herb Demars	Mobil Oil Canada
Donna Dowell	North Canadian Oils Limited
Rob Durward	Enpro
Al Fedkenheuer	NOVA Corporation of Alberta
Travis Ferguson	Alberta Environment
Karl Gilmore	Tera Environmental Consultants (Alta.) Ltd.
Roshan Grover	Alberta Environment
John Hermans	Alberta Agriculture
Mike Houser	NOVA Corporation of Alberta
Arnold Janz	Alberta Environment
John King	Alberta Environment
Len Knapik	Pedocan Land Evaluation Ltd.
Fred Kuipers	Peace Pipe Line Ltd.
Leonard Leskiw	Can-Ag Enterprises Ltd.
Harry Lillo	ERCB
Jim Lore	Jim Lore & Associates Ltd.
Stuart Lunn	PanCanadian Petroleum Ltd.
Terry Macyk	Alberta Research Council
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David McCoy	Husky
Rob McManus	Shell Canada Limited
David McNabb	Alberta Environmental Centre
Gary Mott	Bow Valley Industries
Bob Onciul	Alberta Environment
Dave Paton	Crossfield Laboratories (1987) Ltd.
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Chris Powter	Alberta Environment
Alan Scheibner	Western Oilfield Environmental Services Ltd.
Ian Scott	Canadian Petroleum Association
Bob Seager	NOVA Corporation of Alberta
Howard Slavinski	Alberta Environment
Glen Stalker	Northwestern Utilities Limited
Rob Staniland	BP Canada Inc.
Sam Takyi	Alberta Forestry, Lands and Wildlife
Wayne Tedder	Alberta Forestry, Lands and Wildlife
Al Twardy	Pedocan Land Evaluation Ltd.
Hank Vander Pluym	Alberta Agriculture

RECLAMATION RESEARCH REPORTS

1. **RRTAC 79-2: Proceedings: Workshop on Native Shrubs in Reclamation. P.F. Ziemkiewicz, C.A. Dermott and H.P. Sims (Editors). 104 pp. No longer available.**

The Workshop was organized as the first step in developing a Native Shrub reclamation research program. The Workshop provided a forum for the exchange of information and experiences on three topics: propagation; outplanting; and, species selection. Seven papers and the results of three discussion groups are presented.

2. **RRTAC 80-1: Test Plot Establishment: Native Grasses for Reclamation. R.S. Sadasivaiah and J. Weijer. 19 pp. No longer available.**

The report details the species used at three test plots in Alberta's Eastern Slopes (one at Caw Creek Ridge and two at Cadomin). Site preparation, experimental design, and planting method are also described.

3. **RRTAC 80-3: The Role of Organic Compounds in Salinization of Plains Coal Mining Sites. N.S.C. Cameron et al. 46 pp. $10.00**

This is a literature review of the chemistry of sodic mine spoil and the changes expected to occur in groundwater.

4. **RRTAC 80-4: Proceedings: Workshop on Reconstruction of Forest Soils in Reclamation. P.F. Ziemkiewicz, S.K. Takyi and H.F. Regier (Editors). 160 pp. $10.00**

Experts in the field of forestry and forest soils report on research relevant to forest soil reconstruction and discuss the most effective means of restoring forestry capability of mined lands.

5. **RRTAC 80-5: Manual of Plant Species Suitability for Reclamation in Alberta. L.E. Watson, R.W. Parker and D.F. Polster. 2 vols, 541 pp. No longer available; replaced by RRTAC 89-4.**

Forty-three grass, fourteen forb, and thirty-four shrub and tree species are assessed in terms of their suitability for use in reclamation. Range maps, growth habit, propagation, tolerance, and availability information are provided.

6. **RRTAC 81-2: 1980 Survey of Reclamation Activities in Alberta. D.G. Walker and R.L. Rothwell. 76 pp. $10.00**

This survey is an update of a report prepared in 1976 on reclamation activities in Alberta, and includes research and operational reclamation, locations, personnel, etc.

7. **RRTAC 81-3: Proceedings: Workshop on Coal Ash and Reclamation. P.F. Ziemkiewicz, R. Stein, R. Leitch and G. Lutwick (Editors). 253 pp. $10.00**

Presents nine technical papers on the chemical, physical, and engineering properties of Alberta fly and bottom ashes, revegetation of ash disposal sites, and use of ash as a soil amendment. Workshop discussions and summaries are also included.

8. **RRTAC 82-1: Land Surface Reclamation: An International Bibliography. H.P. Sims and C.B. Powter. 2 vols, 292 pp. $10.00**

Literature to 1980 pertinent to reclamation in Alberta is listed in Vol. 1 and is also on the University of Alberta computing system (in a SPIRES database called RECLAIM). Vol. 2 comprises the keyword index and computer access manual.

9. **RRTAC 82-2: A Bibliography of Baseline Studies in Alberta: Soils, Geology, Hydrology and Groundwater. C.B. Powter and H.P. Sims. 97 pp. $5.00**

This bibliography provides baseline information for persons involved in reclamation research or in the preparation of environmental impact assessments. Materials, up to date as of December 1981, are available in the Alberta Environment Library.

10. **RRTAC 83-1: Soil Reconstruction Design for Reclamation of Oil Sand Tailings. Monenco Consultants Ltd. 185 pp. No longer available**

Volumes of peat and clay required to amend oil sand tailings were estimated based on existing literature. Separate soil prescriptions were made for spruce, jack pine, and herbaceous cover types. The estimates form the basis of field trials.

11. **RRTAC 83-3: Evaluation of Pipeline Reclamation Practices on Agricultural Lands in Alberta. Hardy Associates (1978) Ltd. 205 pp. No longer available.**

Available information on pipeline reclamation practices was reviewed. A field survey was then conducted to determine the effects of pipe size, age, soil type, construction method, etc. on resulting crop production.

12. **RRTAC 83-4: Proceedings: Effects of Coal Mining on Eastern Slopes Hydrology. P.F. Ziemkiewicz (Editor). 123 pp. $10.00**

Technical papers are presented dealing with the impacts of mining on mountain watersheds, their flow characteristics, and resulting water quality. Mitigative measures and priorities were also discussed.

13. **RRTAC 83-5: Woody Plant Establishment and Management for Oil Sands Mine Reclamation. Techman Engineering Ltd. 124 pp. No longer available.**

This is a review and analysis of information on planting stock quality, rearing techniques, site preparation, planting, and procedures necessary to ensure survival of trees and shrubs in oil sand reclamation.

14. **RRTAC 84-1: Land Surface Reclamation: A Review of the International Literature. H.P. Sims, C.B. Powter and J.A. Campbell. 2 vols, 1549 pp. $20.00**

Nearly all topics of interest to reclamationists including mining methods, soil amendments, revegetation, propagation and toxic materials are reviewed in light of the international literature.

15. **RRTAC 84-2: Propagation Study: Use of Trees and Shrubs for Oil Sand Reclamation. Techman Engineering Ltd. 58 pp. $10.00**

This report evaluates and summarizes all available published and unpublished information on large-scale propagation methods for shrubs and trees to be used in oil sand reclamation.

16. **RRTAC 84-3: Reclamation Research Annual Report - 1983. P.F. Ziemkiewicz. 42 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

17. **RRTAC 84-4: Soil Microbiology in Land Reclamation. D. Parkinson, R.M. Danielson, C. Griffiths, S. Visser and J.C. Zak. 2 vols, 676 pp. $10.00**

This is a collection of five reports dealing with re-establishment of fungal decomposers and mycorrhizal symbionts in various amended spoil types.

18. **RRTAC 85-1: Proceedings: Revegetation Methods for Alberta's Mountains and Foothills. P.F. Ziemkiewicz (Editor). 416 pp. $10.00**

Results of long-term experiments and field experience on species selection, fertilization, reforestation, topsoiling, shrub propagation and establishment are presented.

19. **RRTAC 85-2: Reclamation Research Annual Report - 1984. P.F. Ziemkiewicz. 29 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

20. **RRTAC 86-1: A Critical Analysis of Settling Pond Design and Alternative Technologies. A. Somani. 372 pp. $10.00**

The report examines the critical issue of settling pond design, and sizing and alternative technologies. The study was co-funded with The Coal Association of Canada.

21. **RRTAC 86-2: Characterization and Variability of Soil Reconstructed after Surface Mining in Central Alberta. T.M. Macyk. 146 pp. No longer available.**

Reconstructed soils representing different materials handling and replacement techniques were characterized, and variability in chemical and physical properties was assessed. The data obtained indicate that reconstructed soil properties are determined largely by parent material characteristics and further tempered by materials handling procedures. Mining tends to create a relatively homogeneous soil landscape in contrast to the mixture of diverse soils found before mining.

22. **RRTAC 86-3: Generalized Procedures for Assessing Post-Mining Groundwater Supply Potential in the Plains of Alberta - Plains Hydrology and Reclamation Project. M.R. Trudell and S.R. Moran. 30 pp. $5.00**

In the Plains region of Alberta, the surface mining of coal generally occurs in rural, agricultural areas in which domestic water supply requirements are met almost entirely by groundwater. Consequently, an important aspect of the capability of reclaimed lands to satisfy the needs of a residential component is the post-mining availability of groundwater. This report proposes a sequence of steps or procedures to identify and characterize potential post-mining aquifers.

23. **RRTAC 86-4: Geology of the Battle River Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze, R. Li, M. Fenton and S.R. Moran. 86 pp. $10.00**

This report summarizes the geological setting of the Battle River study site. It is designed to provide a general understanding of geological conditions adequate to establish a framework for hydrogeological and general reclamation studies. The report is not intended to be a detailed synthesis such as would be required for mine planning purposes.

24. **RRTAC 86-5: Chemical and Mineralogical Properties of Overburden: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 71 pp. $10.00**

This report describes the physical and mineralogical properties of overburden materials in an effort to identify individual beds within the bedrock overburden that might be significantly different in terms of reclamation potential.

25. **RRTAC 86-6: Post-Mining Groundwater Supply at the Battle River Site: Plains Hydrology and Reclamation Project. M.R. Trudell, G.J. Sterenberg and S.R. Moran. 49 pp. $5.00**

The report deals with the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is in the Battle River Mining area in east-central Alberta.

26. **RRTAC 86-7: Post-Mining Groundwater Supply at the Highvale Site: Plains Hydrology and Reclamation Project. M.R. Trudell. 25 pp. $5.00**

This report evaluates the availability of water supply in or beneath cast overburden to support post-mining land use, including both quantity and quality considerations. The study area is the Highvale mining area in west-central Alberta.

27. **RRTAC 86-8: Reclamation Research Annual Report - 1985. P.F. Ziemkiewicz. 54 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

28. **RRTAC 86-9: Wildlife Habitat Requirements and Reclamation Techniques for the Mountains and Foothills of Alberta. J.E. Green, R.E. Salter and D.G. Walker. 285 pp. No longer available.**

This report presents a review of relevant North American literature on wildlife habitats in mountain and foothills biomes, reclamation techniques, potential problems in wildlife habitat reclamation, and potential habitat assessment methodologies. Four biomes (Alpine, Subalpine, Montane, and Boreal Uplands) and 10 key wildlife species (snowshoe hare, beaver, muskrat, elk, moose, caribou, mountain goat, bighorn sheep, spruce grouse, and white-tailed ptarmigan) are discussed. The study was co-funded with The Coal Association of Canada.

29. **RRTAC 87-1: Disposal of Drilling Wastes. L.A. Leskiw, E. Reinl-Dwyer, T.L. Dabrowski, B.J. Rutherford and H. Hamilton. 210 pp. No longer available.**

Current drilling waste disposal practices are reviewed and criteria in Alberta guidelines are assessed. The report also identifies research needs and indicates mitigation measures. A manual provides a decision-making flowchart to assist in selecting methods of environmentally safe waste disposal.

30. **RRTAC 87-2: Minesoil and Landscape Reclamation of the Coal Mines in Alberta's Mountains and Foothills. A.W. Fedkenheuer, L.J. Knapik and D.G. Walker. 174 pp. $10.00**

This report reviews current reclamation practices with regard to site and soil reconstruction and re-establishment of biological productivity. It also identifies research needs in the Mountain-Foothills area. The study was co-funded with The Coal Association of Canada.

31. **RRTAC 87-3: Gel and Saline Drilling Wastes in Alberta: Workshop Proceedings. D.A. Lloyd (Compiler). 218 pp. No longer available.**

Technical papers were presented which describe: mud systems used and their purpose; industrial constraints; government regulations, procedures and concerns; environmental considerations in waste disposal; and toxic constituents of drilling wastes. Answers to a questionnaire distributed to participants are included in an appendix.

32. **RRTAC 87-4: Reclamation Research Annual Report - 1986. 50 pp. $5.00**

This report details the Reclamation Research Program indicating priorities, descriptions of each research project, researchers, results, and expenditures.

33. **RRTAC 87-5: Review of the Scientific Basis of Water Quality Criteria for the East Slope Foothills of Alberta. Beak Associates Consulting Ltd. 46 pp. $10.00**

The report reviews existing Alberta guidelines to assess the quality of water drained from coal mine sites in the East Slope Foothills of Alberta. World literature was reviewed within the context of the East Slopes environment and current mining operations. The ability of coal mine operators to meet the various guidelines is discussed. The study was co-funded with The Coal Association of Canada.

34. **RRTAC 87-6: Assessing Design Flows and Sediment Discharge on the Eastern Slopes. Hydrocon Engineering (Continental) Ltd. and Monenco Consultants Ltd. 97 pp. $10.00**

The report provides an evaluation of current methodologies used to determine sediment yields due to rainfall events in well-defined areas. Models are available in Alberta to evaluate water and sediment discharge in a post-mining situation. SEDIMOT II (Sedimentology Disturbed Modelling Techniques) is a single storm model that was developed specifically for the design of sediment control structures in watersheds disturbed by surface mining and is well suited to Alberta conditions. The study was co-funded with The Coal Association of Canada.

35. **RRTAC 87-7: The Use of Bottom Ash as an Amendment to Sodic Spoil. S. Fullerton. 83 pp. No longer available.**

The report details the use of bottom ash as an amendment to sodic coal mine spoil. Several rates and methods of application of bottom ash to sodic spoil were tested to determine which was the best at reducing the effects of excess sodium and promoting crop growth. Field trials were set up near the Vesta mine in East Central Alberta using ash readily available from a nearby coal-fired thermal generating station. The research indicated that bottom ash incorporated to a depth of 30 cm using a subsoiler provided the best results.

36. **RRTAC 87-8: Waste Dump Design for Erosion Control. R.G. Chopiuk and S.E. Thornton. 45 pp. $5.00**

This report describes a study to evaluate the potential influence of erosion from reclaimed waste dumps on downslope environments such as streams and rivers. Sites were selected from coal mines in Alberta's mountains and foothills, and included resloped dumps of different configurations and ages, and having different vegetation covers. The study concluded that the average annual amount of surface erosion is minimal. As expected, erosion was greatest on slopes which were newly regraded. Slopes with dense grass cover showed no signs of erosion. Generally, the amount of erosion decreased with time, as a result of initial loss of fine particles, the formation of a weathered surface, and increased vegetative cover.

37. **RRTAC 87-9: Hydrogeology and Groundwater Chemistry of the Battle River Mining Area. M.R. Trudell, R.L. Faught and S.R. Moran. 97 pp. No longer available.**

This report describes the premining geologic conditions in the Battle River coal mining area including the geology as well as the groundwater flow patterns, and the groundwater quality of a sequence of several water-bearing formations extending from the surface to a depth of about 100 metres.

38. **RRTAC 87-10: Soil Survey of the Plains Hydrology and Reclamation Project - Battle River Project Area. T.M. Macyk and A.H. MacLean. 62 pp. plus 8 maps. $10.00**

The report evaluates the capability of post-mining landscapes and assesses the changes in capability as a result of mining, in the Battle River mining area. Detailed soils information is provided in the report for lands adjacent to areas already mined as well as for lands that are destined to be mined. Characterization of the reconstructed soils in the reclaimed areas is also provided. Data were collected from 1979 to 1985. Eight maps supplement the report.

39. **RRTAC 87-11: Geology of the Highvale Study Site: Plains Hydrology and Reclamation Project. A. Maslowski-Schutze. 78 pp. $10.00**

The report is one of a series that describes the geology, soils and groundwater conditions at the Highvale Coal Mine study site. The purpose of the study was to establish a summary of site geology to a level of detail necessary to provide a framework for studies of hydrogeology and reclamation.

40. **RRTAC 87-12: Premining Groundwater Conditions at the Highvale Site. M.R. Trudell and R. Faught. 83 pp. $10.00**

This report presents a detailed discussion of the premining flow patterns, hydraulic properties, and isotopic and hydrochemical characteristics of five layers within the Paskapoo Geological Formation, the underlying sandstone beds of the Upper Horseshoe Canyon Formation, and the surficial glacial drift.

41. **RRTAC 87-13: An Agricultural Capability Rating System for Reconstructed Soils. T.M. Macyk. 27 pp. $5.00**

This report provides the rationale and a system for assessing the agricultural capability of reconstructed soils. Data on the properties of the soils used in this report are provided in RRTAC 86-2.

42. **RRTAC 88-1: A Proposed Evaluation System for Wildlife Habitat Reclamation in the Mountains and Foothills Biomes of Alberta: Proposed Methodology and Assessment Handbook. T.R. Eccles, R.E. Salter and J.E. Green. 101 pp. plus appendix. $10.00**

The report focuses on the development of guidelines and procedures for the assessment of reclaimed wildlife habitat in the Mountains and Foothills regions of Alberta. The technical section provides background documentation including a discussion of reclamation planning, a listing of reclamation habitats and associated key wildlife species, conditions required for development, recommended revegetation species, suitable reclamation techniques, a description of the recommended assessment techniques and a glossary of basic terminology. The assessment handbook section contains basic information necessary for evaluating wildlife habitat reclamation, including assessment scoresheets for 15 different reclamation habitats, standard methodologies for measuring habitat variables used as assessment criteria, and minimum requirements for certification. This handbook is intended as a field manual that could potentially be used by site operators and reclamation officers. The study was co-funded with The Coal Association of Canada.

43. **RRTAC 88-2: Plains Hydrology and Reclamation Project: Spoil Groundwater Chemistry and its Impacts on Surface Water. M.R. Trudell (Compiler). 135 pp. $10.00**

Two reports comprise this volume. The first "Chemistry of Groundwater in Mine Spoil, Central Alberta," describes the chemical make-up of spoil groundwater at four mines in the Plains of Alberta. It explains the nature and magnitude of changes in groundwater chemistry following mining and reclamation. The second report, "Impacts of Surface Mining on Chemical Quality of Streams in the Battle River Mining Area," describes the chemical quality of water in streams in the Battle River mining area, and the potential impact of groundwater discharge from surface mines on these streams.

44. **RRTAC 88-3: Revegetation of Oil Sands Tailings: Growth Improvement of Silver-berry and Buffalo-berry by Inoculation with Mycorrhizal Fungi and N_2-Fixing Bacteria. S. Visser and R.M. Danielson. 98 pp. $10.00**

The report provides results of a study: (1) To determine the mycorrhizal affinities of various actinorrhizal shrubs in the Fort McMurray, Alberta region; (2) To establish a basis for justifying symbiont inoculation of buffalo-berry and silver-berry; (3) To develop a growing regime for the greenhouse production of mycorrhizal, nodulated silver-berry and buffalo-berry; and, (4) To conduct a field trial on reconstructed soil on the Syncrude Canada Limited oil sands site to critically evaluate the growth performance of inoculated silver-berry and buffalo-berry as compared with their un-inoculated counterparts.

45. **RRTAC 88-4: Plains Hydrology and Reclamation Project: Investigation of the Settlement Behaviour of Mine Backfill. D.R. Pauls (compiler). 135 pp. $10.00**

This three part volume covers the laboratory assessment of the potential for subsidence in reclaimed landscapes. The first report in this volume, "Simulation of Mine Spoil Subsidence by Consolidation Tests," covers laboratory simulations of the subsidence process particularly as it is influenced by resaturation of mine spoil. The second report, "Water Sensitivity of Smectitic Overburden: Plains Region of Alberta," describes a series of laboratory tests to determine the behaviour of overburden materials when brought into contact with water. The report entitled "Classification System for Transitional Materials: Plains Region of Alberta," describes a lithological classification system developed to address the characteristics of the smectite rich, clayey transition materials that make up the overburden in the Plains of Alberta.

46. **RRTAC 88-5: Ectomycorrhizae of Jack Pine and Green Alder: Assessment of the Need for Inoculation, Development of Inoculation Techniques and Outplanting Trials on Oil Sand Tailings. R.M. Danielson and S. Visser. 177 pp. $10.00**

The overall objective of this research was to characterize the mycorrhizal status of Jack Pine and Green Alder which are prime candidates as reclamation species for oil sand tailings and to determine the potential benefits of mycorrhizae on plant performance. This entailed determining the symbiont status of container-grown nursery stock and the quantity and quality of inoculum in reconstructed soils, developing inoculation techniques and finally, performance testing in an actual reclamation setting.

47. **RRTAC 88-6: Reclamation Research Annual Report - 1987. Reclamation Research Technical Advisory Committee. 67 pp. No longer available.**

This annual report describes the expenditure of $500,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

48. **RRTAC 88-7: Baseline Growth Performance Levels and Assessment Procedure for Commercial Tree Species in Alberta's Mountains and Foothills. W.R. Dempster and Associates Ltd. 66 pp. $5.00**

Data on juvenile height development of lodgepole pine and white spruce from cut-over or burned sites in the Eastern Slopes of Alberta were used to define reasonable expectations of early growth performance as a basis for evaluating the success of reforestation following coal mining. Equations were developed predicting total seedling height and current annual height increment as a function of age and elevation. Procedures are described for applying the equations, with further adjustments for drainage class and aspect, to develop local growth performance against these expectations. The study was co-funded with The Coal Association of Canada.

49. **RRTAC 88-8: Alberta Forest Service Watershed Management Field and Laboratory Methods. A.M.K. Nip and R.A. Hursey. 4 Sections, various pagings. $10.00**

Disturbances such as coal mines in the Eastern Slopes of Alberta have the potential for affecting watershed quality during and following mining. The collection of hydrometric, water quality and hydrometeorologic information is a complex task. A variety of instruments and measurement methods are required to produce a record of hydrologic inputs and outputs for a watershed basin. There is a growing awareness and recognition that standardization of data acquisition methods is required to ensure data comparability, and to allow comparison of data analyses. The purpose of this manual is to assist those involved in the field of data acquisition by outlining methods, practices and instruments which are reliable and recognized by the International Organization for Standardization.

50. **RRTAC 88-9: Computer Analysis of the Factors Influencing Groundwater Flow and Mass Transport in a System Disturbed by Strip Mining. F.W. Schwartz and A.S. Crowe. 78 pp. $10.00**

Work presented in this report demonstrates how a groundwater flow model can be used to study a variety of mining-related problems such as declining water levels in areas around the mine as a result of dewatering, and the development of high water tables in spoil once resaturation is complete. This report investigates the role of various hydrogeological parameters that influence the magnitude, timing, and extent of water level changes during and following mining at the regional scale. The modelling approach described here represents a major advance on existing work.

51. **RRTAC 88-10: Review of Literature Related to Clay Liners for Sump Disposal of Drilling Wastes. D.R. Pauls, S.R. Moran and T. Macyk. 61 pp. $5.00**

The report reviews and analyses the effectiveness of geological containment of drilling waste in sumps. Of particular importance was the determination of changes in properties of clay materials as a result of contact with highly saline brines containing various organic chemicals.

52. **RRTAC 88-11: Highvale Soil Reconstruction Project: Five Year Summary. D.N. Graveland, T.A. Oddie, A.E. Osborne and L.A. Panek. 104 pp. $10.00**

This report provides details of a five year study to determine a suitable thickness of subsoil to replace over minespoil in the Highvale plains coal mine area to ensure return of agricultural capability. The study also examined the effect of slope and aspect on agricultural capability. This study was funded and managed with industry assistance.

53. **RRTAC 88-12: A Review of the International Literature on Mine Spoil Subsidence. J.D. Scott, G. Zinter, D.R. Pauls and M.B. Dusseault. 36 pp. $10.00**

The report reviews available engineering literature relative to subsidence of reclaimed mine spoil. The report covers methods for site investigation, field monitoring programs and lab programs, mechanisms of settlement, and remedial measures.

54. **RRTAC 89-1: Reclamation Research Annual Report - 1988. 74 pp. $5.00**

This annual report describes the expenditure of $280,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

55. **RRTAC 89-2: Proceedings of the Conference: Reclamation, A Global Perspective. D.G. Walker, C.B. Powter and M.W. Pole (Compilers). 2 Vols., 854 pp. $10.00**

Over 250 delegates from all over the world attended this conference held in Calgary in August, 1989. The proceedings contains over 85 peer-reviewed papers under the following headings: A Global Perspective; Northern and High Altitude Reclamation; Fish & Wildlife and Rangeland Reclamation; Water; Herbaceous Revegetation; Woody Plant Revegetation and Succession; Industrial and Urban Sites; Problems and Solutions; Sodic and Saline Materials; Soils and Overburden; Acid Generating Materials; and, Mine Tailings.

56. **RRTAC 89-3: Efficiency of Activated Charcoal for Inactivation of Bromacil and Tebuthiuron Residues in Soil. M.P. Sharma. 38 pp. $5.00**

Bromacil and Tebuthiuron were commonly used soil sterilants on well sites, battery sites and other industrial sites in Alberta where total vegetation control was desired. Activated charcoal was found to be effective in binding the sterilants in greenhouse trials. The influence of factors such as herbicide:charcoal concentration ratio, soil texture, organic matter content, soil moisture, and the time interval between charcoal incorporation and plant establishment were evaluated in the greenhouse.

57. **RRTAC 89-4: Manual of Plant Species Suitability for Reclamation in Alberta - 2nd Edition. Hardy BBT Limited. 436 pp. $10.00**

This is an updated version of RRTAC Report 80-5 which describes the characteristics of 43 grass, 14 forb and 34 shrub and tree species which make them suitable for reclamation in Alberta. The report has been updated in several important ways: a line drawing of each species has been added; the range maps for each species have been redrawn based on an ecosystem classification of the province; new information (to 1990) has been added, particularly in the sections on reclamation use; and the material has been reorganized to facilitate information retrieval. Of greatest interest is the performance chart that precedes each species and the combined performance charts for the grass, forb, and shrub/tree groups. These allow the reader to pick out at a glance species that may suit their particular needs. The report was produced with the assistance of a grant from the Recreation, Parks and Wildlife Foundation.

58. **RRTAC 89-5: Battle River Soil Reconstruction Project Five Year Summary. L.A. Leskiw. 188 pp. $10.00**

This report summarizes the results of a five year study to investigate methods required to return capability to land surface mined for coal in the Battle River area of central Alberta. Studies were conducted on: the amounts of subsoil required, the potential of gypsum and bottom ash to amend adverse soil properties, and the effects of slope angle and aspect. Forage and cereal crop growth was evaluated, as were changes in soil chemistry, density and moisture holding characteristics.

59. **RRTAC 89-6: Detailed Sampling, Characterization and Greenhouse Pot Trials Relative to Drilling Wastes in Alberta. T.M. Macyk, F.I. Nikiforuk, S.A. Abboud and Z.W. Widtman. 228 pp. $10.00**

This report summarizes a three-year study of the chemistry of freshwater gel, KCl, NaCl, DAP, and invert drilling wastes, both solids and liquids, from three regions in Alberta: Cold Lake, Eastern Slopes, and Peace River/Grande Prairie. A greenhouse study also examined the effects of adding various amounts of waste to soil on grass growth and soil chemistry. Methods for sampling drilling wastes are recommended.

60. **RRTAC 89-7: A User's Guide for the Prediction of Post-Mining Groundwater Chemistry from Overburden Characteristics. M.R. Trudell and D.C. Cheel. 55 pp. $5.00**

This report provides the detailed procedure and methodology that is required to produce a prediction of post-mining groundwater chemistry for plains coal mines, based on the soluble salt characteristics of overburden materials. The fundamental component of the prediction procedure is the geochemical model PHREEQE, developed by the U.S. Geological Survey, which is in the public domain and has been adapted for use on personal computers.

61. **RRTAC 90-1: Reclamation Research Annual Report - 1989. 62 pp. $5.00**

This annual report describes the expenditure of $480,000.00 of Alberta Heritage Savings Trust Fund monies on research under the Land Reclamation Program. The report outlines the objectives and research strategies of the four program areas, and describes the projects funded under each program.

62. **RRTAC 90-2: Initial Selection for Salt Tolerance in Rocky Mountain Accessions of Slender Wheatgrass and Alpine Bluegrass. R. Hermesh, J. Woosaree, B.A. Darroch, S.N. Acharya and A. Smreciu. 40 pp. $5.00**

Selected lines of slender wheatgrass and alpine bluegrass collected from alpine and subalpine regions of Alberta as part of another native grass project were evaluated for their ability to emerge in a saline medium. Eleven slender wheatgrass and 72 alpine bluegrass lines had a higher percentage emergence than the Orbit Tall Wheatgrass control (a commonly available commercial grass). This means that as well as an ability to grow in high elevation areas, these lines may also be suitable for use in areas where saline soil conditions are present. Thus, their usefulness for reclamation has expanded.

63. **RRTAC 90-3: Natural Plant Invasion into Reclaimed Oil Sands Mine Sites. Hardy BBT Limited. 65 pp. $5.00**

Vegetation data from reclaimed sites on the Syncrude and Suncor oil sands mines have been summarized and related to site and factors and reclamation methods. Natural invasion into sites seeded to agronomic grasses and legumes was minimal even after 15 years. Invasion was slightly greater in sites seeded to native species, but was greatest on sites that were not seeded. Invasion was mostly from agronomic species and native forbs; native shrub and tree invasion was minimal.

64. **RRTAC 90-4: Physical and Hydrological Characteristics of Ponds in Reclaimed Upland Landscape Settings and their Impact on Agricultural Capability. Moran, S.R., T.M. Macyk, M.R. Trudell and M.E. Pigot, Alberta Research Council. 76 pp. $5.00**

The report details the results and conclusions from studying a pond in a reclaimed upland site in Vesta Mine. The pond formed as a result of two factors: (1) a berm which channelled meltwater into a series of subsidence depressions, forming a closed basin; and (2) low hydraulic conductivity in the lower subsoil and upper spoil as a result of compaction during placement and grading which did not allow for rapid drainage of ponded water. Ponds such as this in the reclaimed landscape can affect agricultural capability by: (1) reducing the amount of farmable land (however, the area covered by these ponds in this region is less than half of that found in unmined areas); and, (2) creating the conditions necessary for the progressive development of saline and potentially sodic soils in the area adjacent to the pond.

65. **RRTAC 90-5: Review of the Effects of Storage on Topsoil Quality. Thurber Consultants Ltd., Land Resources Network Ltd., and Norwest Soil Research Ltd. 116 pp. $10.00**

The international literature was reviewed to determine the potential effects of storage on topsoil quality. Conclusions from the review indicated that storage does not appear to have any severe and longterm effects on topsoil quality. Chemical changes may be rectified with the use of fertilizers or manure. Physical changes appear to be potentially less serious than changes in soil quality associated with the stripping and respreading operations. Soil biotic populations appear to revert to pre-disturbance levels of activity within acceptable timeframes. Broad, shallow storage piles that are seeded to acceptable grass and legume species are recommended; agrochemical use should be carefully controlled to ensure soil biota are not destroyed.